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Building the CAF Digital Factory: A Guide for the Executive Leadership

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ABSTRACT

There is a consensus across the CAF that digital transformation is required to gain military supremacy within the future battlespace, and that the integration of emerging technology is paramount; however, translating a vision within an emerging domain into tangible objectives and technical actions is challenging. A common first step across the private and public sector is to implement an internal innovation hub - the *Digital Factory*. This research paper is meant to act as a guide for executive leadership on how to implement a successful digital factory within the CAF to accelerate digital transformation. By explaining various strategic and technical concepts, the reader will be able to understand how the various pieces of the digital transformation puzzle tie in together, and understand how the digital factory acts as a catalyst for change. Leveraging three distinct success stories across military organizations (Gradient Ascent, Global Analytics Platform, and Kessel Run), it will highlight the various factors leading to success, key lessons-learned, and potential challenges. It also proposes a recommended organizational structure of a CAF digital factory.

LIST OF ABREVIATIONS

Artificial Intelligence (AI)

Army Future Command (AFC)

Canadian Armed Forces (CAF)

Canadian Special Operations Forces Command (CANSOFCOM)

Chief Data Officer (CDO)

Commercial-of-the-Shelf (COTS)

Continuous Integration (CI)

Continuous Delivery (CD)

Customer Value Proposition (CVP)

Department of National Defence (DND)

Direction and Guidance (D&G)

Global Analytics Platform (GAP)

Government of Canada (GoC)

Gradient Ascent (GradA)

Kessel Run (KR)

Key Leadership Engagement (KLE)

Minimum Viable Product (MVP)

Operational Effectiveness (OE)

Quality Assurance (QA)

Strong Secure Engage (SSE)

United States Special Operations Command (USSOCOM)

CHAPTER 0: INTRODUCTION

There is no alternative to digital transformation. Visionary companies will carve out new strategic options for themselves — those that don't adapt, will fail."

— Jeff Bezos, Amazon

If implementing a digital transformation was simply a question of following the processes in a book or replicating the methodology of the most successful Silicon Valley companies, every organization would resemble Google or Apple; however, one can deduce from personal experience or readings that digital transformation is hard and expensive. Investments in digital transformation are plagued by a significant failure rate. Business articles and academic research often refer to a 70 to 90% failure rate across transformation initiatives. [1,2] Although the exact study in which these statistics are sourced could not be found, it can be assumed that the likelihood of a digital transformation initiative to succeed is low. Nevertheless, digital transformation is a necessity and lucrative market.

The International Data Corporation, a market intelligence firm, estimates the global market for digital transformation to reach $2.8 trillion by 2024.[3] From a survey conducted by New Vantage Partner across 60 firms within the Fortune 1000 companies, 97% of the respondents claimed to be investing in data analytics through Artificial Intelligence (AI) and Big Data projects.[4] These massive investments are tied to the modernization needs of

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[1] Harry Robinson, "Why do most transformations fail? A conversation with Harry Robinson." last modified 10 July 2019, https://www.mckinsey.com/business-functions/transformation/our-insights/why-do-most-transformations-fail-a-conversation-with-harry-robinson

[2] Nagesh Ramesh and D. Delen, "Digital Transformation: How to Beat the 90% Failure Rate?" - *IEEE Engineering Management Review* 49, no. 3 (2021), 22. doi:10.1109/EMR.2021.3070139. https://ieeexplore-ieee-org.cfc.idm.oclc.org/document/9408371.

[3] International Data Corporation, "New IDC Spending Guide Shows Continued Growth for Digital Transformation as Organizations Focus on Strategic Priorities." Last modified 09 Nov 2021, https://www.idc.com/getdoc.jsp?containerId=prUS48372321

[4] Thomas H. Davenport and R.Bean. "Data and innovation: How Big Data and AI are driving business innovation. New Vantage Partners LLC." (2018), 3

organizations to remain relevant within an increasingly competitive market. At the time of the survey, more than 79.4% of the executives interviewed had concerns about the "threat of disruption and displacement" of the economic sector by big technology giants.[5] In fact, there has been an ongoing trend since the beginning of Covid-19, where the top quartile companies have "a more aggressive and holistic agenda for tech transformations, greater involvement by tech leaders in business strategy, and a more proactive approach to people development".[6] Technology has become a fundamental pillar of success.

The Government of Canada (GoC) and the Department of National Defence (DND) are also challenged by this new reality. Although the pace of change will not jeopardize its existence, it will challenge its relevance as a nation to compete against foreign pressures and threats.[7] In a world of great power competition, countries such as China are investing significantly in the development of emerging technology to support their strategic objectives and to modernize their military power.[8] It is argued that military dominance will be highly dependent on a country's ability to integrate and leverage new technologies such as AI[9]; therefore, for a middle power like Canada, digital transformation is directly tied to its ability to compete, especially within the military domain.

The Canadian Armed Forces (CAF) leadership recognized the need to embrace digital transformation to operate in the pan-domain environment.[10] The departmental

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[5] *Ibid.,* 7.

[6] Anusha Dhasarathy, Ross Frazier, Naufal Khan, and Kristen Steagall. "Prioritizing Technology Transformations to Win." *McKinsey Insights* (2022). https://go.exlibris.link/dJPPrdQK.

[7] James Johnson. "Artificial Intelligence & Future Warfare: Implications for International Security." Defense & Security Analysis 35, no. 2 (2019), 147-148.

[8] James Johnson. "Artificial Intelligence & Future Warfare: Implications for International Security." Defense & Security Analysis 35, no. 2 (2019), 148.

[9] Amandeep S. Gill. "Artificial Intelligence and International Security: The Long View." Ethics & International Affairs 33, no. 2 (2019), 169.

[10] LGen Frances Allen (speech, Vanguard C4ISR and Beyond, Ottawa, Canada, 27 January 2022.

policy, Strong Secure Engage (SSE), emphasizes the disruptive nature of emerging technology within future conflicts. The CAF's various environmental elements also emphasize this issue within their own strategy documents. In 2020, The Canadian Special Operations Forces Command (CANSOFCOM) released its strategy document highlighting the necessity to embrace agility and innovation to compete in the evolving security environment. [11] This strategy reinforces the need to be flexible, to be enabled by technology, to be driven to innovate and learn by experimentation, to fail fast and adjust, and to focus on modernization and optimization of operational effectiveness.[12] As a result, CANSOFCOM established a digitalization and data analytics initiative named Gradient Ascent (GradA). This program "changed the game" in the way that CANSOFCOM develops its software and solves data problems through insourcing via its own digital factory. GradA is the inspiration behind this defence research paper.

The motivation for this research was to identify the conditions, models, and theoretical frameworks that can support a digital factory's path to success. Leveraging literature and interviews, this essay will attempt to identify commonalities between programs and how a military digital factory can achieve success. This paper will refer to four use cases:

> Gradient Ascent (GradA) – CANSOFCOM's digital transformation program. This program focuses on data analytics for decision-making, agile software development through DevSecOps practices, and data infrastructure modernization. This program supports various value streams ranging from operations to intelligence to enterprise management. It delivers new applications to the SOF community on a weekly basis,

[11] Canada. Department of National Defence. *CANSOFCOM – Beyond the Horizon* (Ottawa: Canada Communication Group, 2020), 31.

[12] Ibid, 31.

but also enables the development and release of prototypes daily. Moreover, it provides dynamic analytics products leveraging data from CANSOFCOM IT systems and sensors, enabling accelerated decision-making.

Global Analytics Platform (GAP) – One of USSOCOM's digital factories. It leverages data science, agile software development, and DevSecOps practices to solve big-data challenges in support of the SOF operations and intelligence community.[13] Information in this paper will be based on interviews with former and current members of this program.

KesselRun – A United States Air Force (USAF) digital factory that delivers insourced software development capability that "builds, tests, delivers, operates and maintains cloud-based infrastructure and warfighting software applications" for use by airmen in operations.[14] It leverages Agile and DevSecOps principles to deliver software tailored to the execution of air operations.[15] Information from this program is based on open-source information.

Platform One – This program is a sub-component of the DoD Enterprise DevSecOps initiative. Platform One consists of "DOD-wide DevSecOps managed services" that provide the cloud-based environment and tooling necessary for digital factories to implement and conduct DevSecOps.[16] This platform enables the establishment of Continuous Integration (CI) and Continuous Delivery (CD) pipelines, the support to cloud-native applications delivery, and the security

[13] Former Global Analytics Platform Director, MSTeams interview with author, 19 January 2022.
[14] United States Air Force, "Kessel Run," last accessed 01 May 2022, https://kesselrun.af.mil/
[15] *Ibid, https://kesselrun.af.mil/product-lines/OpsC2.html#weapon-system*
[16] "DoD Enterprise DevSecOps Initiative and Platform One", Platform One website, posted by the Office of the Chief Software Officer, last accessed 01 May 2022, https://software.af.mil/team/platformone/

guidelines to ensure secure deployment of software into operational networks. Information from this program is available through the website of the Office of the Chief Software Officer of the US Air Force. [17]

As noted in the introduction, certain technical terminology will be used throughout this paper; however, this terminology is essential for understanding and will be explained and contextualized. Nevertheless, this paper's foremost objective is to be a generalist's guide to digital transformation and digital factories. Moreover, as there is no strict recipe for successful implementation and since the individual experiences of organizations may vary, this paper will explore some of the foundational business and technical knowledge required to implement such an initiative. It will make use of academic studies on the topic of digital transformation, change management, Agile, and DevOps. It also uses empirical data from various programs to provide context and hypotheses on how to implement a digital factory as part of a military organization.

This paper argues that to achieve a successful digital transformation, organizations must establish a digital factory. The digital factory will be an ecosystem in which digital talent will support data analytics and the insourcing of software development. This research will be deconstructed into four chapters. (1) The first chapter will explain the foundational concept and theories required to understand the digital transformation ecosystem, digital factories, and the emerging technology supporting such initiative. It will provide technical explanations of concepts, their impact, and the implications in the creation of a CAF digital factory. (2) The second chapter will explore strategic conditions that enable success. It will

[17] United State Air Force, "Office of the Chief Software Officer", last accessed 01 May 2022. https://software.af.mil/

explore strategy building, change management theory, and organizational structure concepts. (3) The third chapter will present the organizational processes of a successful digital factory. It will investigate the importance of the Agile philosophy, Agile product management, and the need to implement a DevSecOps infrastructure to support rapid software development. (4) The fourth chapter will propose a digital factory structure and explore the considerations for choosing the leadership and development teams. It will also investigate lessons learned from US military programs on the recruitment and retention of digital talent. In addition, it will explore US DoD initiatives to bring talent into the government workforce.

CHAPTER 1: CONTEXT AND TECHNICAL CONCEPTS

AI won't replace managers, but managers who use AI will replace those who don't

— Erik Brynjolfsson and Andrew McAfee

A survey from PwC in 2021 identified that more than 50% of the surveyed industry intended to invest more than 10% of their budgets into digital transformation initiatives to secure long-term survivability.[18] The scope of digital transformation is wide and can span across various categories such as AI, autonomous vehicles and robotics, big data analytics, custom manufacturing, IoT and more[19]. This chapter will orient the reader toward implementing a CAF digital factory by exploring what digital transformation means and how it can be accelerated. It will also explain technical concepts such as data analytics and AI, and their dependency on data and cloud computing.

What is Digital Transformation?

Digital Transformation is an umbrella term to encompass the *fuzziness* and ambiguity related to the technological modernization of an organization. Depending on the industry sector or the type of business, its definition may vary. Some will argue that digital transformation is about culture change. Some will argue that it's about the integration of new technologies such as cloud and artificial intelligence. Further, some will say that it's about automating legacy processes with new tools such as Robotic Process Automation

[18] PwC, "24th Annual Global CEO Survey: A Leadership agenda to take on tomorrow," last accessed 05 May 2022, https://www.pwc.com/gx/en/ceo-survey/2021/reports/pwc-24th-global-ceo-survey.pdf

[19] World Economic Forum, "Digital Transformation Initiative: Unlocking $100 Trillion for Business and Society from Digital Transformation", last modified May 2018: 7, http://reports.weforum.org/digital-transformation/wp-content/blogs.dir/94/mp/files/pages/files/dti-executive-summary-20180510.pdf

(RPA). Frankly, these are all correct. One's digital transformation may look different to another. In the end, it must serve the organization in producing value.

Digital Transformation is defined as the "transition from traditional to digital business models"[20], but is broader in the sense that it needs to include both wide adoption of technology and cultural change.[21] The path towards digital transformation includes digitization and digitalization. Gartner defines digitization as the "process of changing from analog to digital form"[22], whereas digitalization is the function of leveraging "digital technologies to change a business model and provide new revenue and value-producing opportunities."[23] In other words, digitization allows the transfer of information and processes into digital form in a way that was previously done outside of IT systems. Digitalization means to leverage digitized information, processes, and technology into a coherent strategy that will provide value and impact. Digital transformation is the deeper change in organizational culture that leverages digitalization as a core enabler.

Another consideration is that the vision related to digital transformation will vary based on the professional and academic background of the managers implementing it. At the extremes, highly technical individuals see digital transformation from a technology adoption standpoint at the risk of limited business value. On the other hand, non-technical

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[20] Matthias Wißotzki, Kurt Sandkuhl, and Johannes Wichmann. "Digital Innovation and Transformation: Approach and Experiences." In Architecting the Digital Transformation, Cham: Springer International Publishing, (2020): 10.

[21] Coleen, "Digitization, Digitalization, and Digital Transformation: What's the Difference?", *Medium* (blog), 18 October 2018, https://colleenchapcowadesafina.medium.com/digitization-digitalization-and-digital-transformation-whats-the-difference-eff1d002fbdf

[22] Gartner, "Digitization", last accessed 05 May 2022, https://www.gartner.com/en/information-technology/glossary/digitization

[23] Gartner, "Digitization", last accessed 05 May 2022, https://www.gartner.com/en/information-technology/glossary/digitalization

business managers and leaders may see the basic digitization of analog processes as revolutionary; thus, limiting the organization's true potential.

It is important to understand that digital transformation is not about technology but is highly dependent on it. "Digital business models are often triggered by technological innovations and lead to entirely new products and services" and therefore, lead to new capabilities.[24] Thus, there is always a "chicken and egg" dynamic between business needs and technology integration. A successful digital transformation strategy will thereby attempt to change the business model and organizational culture by digitizing its processes and interactions, and through a strong digitization effort in the collection and processing of data using various technologies.[25] The implementation of digital transformation can be seen as occurring along four concurrent lines of efforts: *Technology, Strategy, Process,* and *People*.[26] There is also an overarching aspect of culture that spans across all lines of effort.[27]

Technology is the IT infrastructure, the data architecture, the tooling, and the integration of various systems. It is what will enable the organization to generate the most digital value and compound it.

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[24] Matthias Wißotzki, Kurt Sandkuhl, and Johannes Wichmann. "Digital Innovation and Transformation: Approach and Experiences." In Architecting the Digital Transformation, Cham: Springer International Publishing, (2020): 10.

[25] Jason Bloomberg, "Digitization, digitalization, and digital transformation: confuse them at your peril." Forbes. Retrieved on August 28 (2018): 2019.

[26] Boston Consulting Group, "Digital Transformation", last accessed 02 May 2022, https://www.bcg.com/capabilities/digital-technology-data/digital-transformation/overview?utm_source=search&utm_medium=cpc&utm_campaign=digital&utm_description=none&utm_topic=digital_transformation&utm_geo=global&utm_content=digital_transformation_general&gclid=Cj0KCQjwuMuRBhCJARIsAHXdnqOT_8id74qFRSr2Xqi5XGqxeWd7ZDUGon2xCKuN4j3-mvs_4317qtEaAp63EALw_wcB

[27] George Long, "The answer is scale… What's the question", Accenture, last modified 13 October 2021, https://www.accenture.com/us-en/blogs/industry-digitization/the-answer-is-scalewhats-the-question

Strategy will enable the identification of the organization's value proposition, and especially the activities that it will and will not do. Failed digital transformation is often tied to a disconnect between strategy formulation and implementation.[28] Incoherence between the scope of the transformation and the allocated resources, the prioritization of activities, and stakeholder support can impact the likelihood of success.[29]

Process includes all of the business workflows, the internal team methodologies, the prioritization and approval mechanisms, the funding, the contracting, and much more. Digital organizations are agile and empower their people.[30]

Finally, a crucial catalyst to digital transformation is the *people:* those who will make digital transformation feasible. It requires the recruitment, development, and retention of a digital workforce. For the CAF, the digital workforce will be a mix of military members, public servants, and contractors that will work in a highly integrated manner to deliver maximum results.

What is a Digital Factory?

A common saying in the tech sector is "every company is a software company, whether they know it or not." Anecdotally, the receptivity of such quotes by executive leadership often provides an initial idea of where they fit on the spectrum of innovation adoption.

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[28] Alessia Correani et al. "Implementing a digital strategy: Learning from the experience of three digital transformation projects." California Management Review 62, no. 4 (2020): 37.

[29] Bughin, Jacques, Jonathan Deakin, and Barbara O'Beirne. "Digital transformation: Improving the odds of success." *McKinsey Quarterly* 22 (2019). https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/digital-transformation-improving-the-odds-of-success

[30] *Ibid.*

Building innovative software products can be done by either outsourcing to third-party companies, insourcing internally to software development teams, crowdsourcing to individuals or groups outside of the organization, or from open sourcing by making the code available to the community for them to use and improve.[31]

A digital factory, also known as a "software factory" or "coding factory", is a digital task force with the mandate of accelerating the digital transformation of an organization. It does so by supporting the insourcing of resilient software development and other digital capabilities at the speed of relevance. [32] It designs and builds products that support the needs of the business with a creative and innovative approach that would not work outside of this construct. Like physical factories, digital factories implement software assembly lines, which includes the personnel (talent), the tools (technology), the workflows (Agile and DevSecOps methodologies), and the quality-assurance (QA) processes to ensure that the best quality product makes it to the consumer.[33]

A digital factory allows an organisation to meet an ever-increasing need for agility and speed in ways that standard project delivery and procurement do not permit. It is the internal innovative start-up that enables an organisation to innovate and keep up with the digital race. Many hierarchical organisations use digital factories to promote a new digital and agile culture, and attract talent that would normally gravitate to smaller and leaner organizations.[34] Their output ranges from the development of applications enabling

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[31] Nitin Naik. "Crowdsourcing, Open-Sourcing, Outsourcing and Insourcing Software Development: A Comparative Analysis."IEEE, 2016, 381. https://go.exlibris.link/cBHYVWtF.

[32] United States. Department of Defense, DoD Enterprise DevSecOps Strategy Guide, (March 2021), 6.

[33] United States. Department of Defense, DoD Enterprise DevSecOps Strategy Guide, (March 2021), 14.

[34] Rohit Bhapkar., J. Dias, and B. Seitz. "How a digital factory can transform company culture.", Last modified 19 September 2017. https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/how-a-digital-factory-can-transform-company-culture

digitization, analytics products to support decision-making, the integration of third-party capabilities into the digital environment, or any other type of digital initiative that enables the strategy. Nevertheless, the provided services and supported capabilities will change from one organization to the next. Digital factories mostly operate in cross-functional teams and leverage agile software development methodology and DevSecOps processes to accelerate the development and deployment of software into production. These methodologies will be explored in more detail in Chapter 3.

Various industries are implementing digital factories as part of their business model. For example, Loblaw Companies created Loblaw Digital which acts as "the digital arm of a 100-year-old enterprise." [35] Loblaw Digital evolved from a small e-commerce group in 2012 that grew over the years to more than 600 personnel.[36] This digital factory revolutionized Loblaw's food distribution and grocery business by leveraging data and digital applications such as PC Express for groceries, PC Optimum for reward programs, and Digital Pharmacy for shopping through their Shopper's Drug Mart brand.[37] Loblaw embraced the concept of being a software company providing various distribution services.

A military example of successful implementation is the USAF Kessel Run (KR) program. KR's mission is to "continuously deliver war-winning software our airmen love."[38] KR was created out of a failure to deliver a $500M project over a 10-year period.[39]

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[35] Booby Moore, "Meet our seasoned crew", *Medium Loblaw* Digital (blog), 22 Dec 2021, https://medium.com/loblaw-digital/the-launch-of-our-new-website-loblawdigital-co-51e095a0a59e.

[36] *Ibid.*

[37] Loblaw Digital, "What we work on," last accessed 1 Apr 2022, https://www.loblawdigital.co/our-work/

[38] Jenny Aroune, Robert Hollister, and Nathan Taylor. "Kessel Run: An Analysis of the Air Force's Internal Software Development Organization.", Monterey, CA; Naval Postgraduate School, 2019, 32. https://calhoun.nps.edu/handle/10945/63995

[39] *Ibid*, 41.

The alternative solution was the development of an agile-based methodology to insource software development at lower cost while maintaining control over the delivery schedule.[40] The KR program maintains three main product lines: supporting air campaign mission planning, battle management, and data-driven decision-making.[41] One of KR's most famous applications is JIGSAW, an air refuelling planning tool. Since its creation in 2017, "it has helped save the DoD more than $500 million dollars in fuel costs and greatly reduced the time associated with planning refuelling missions, enhancing combat capabilities through its increased coordination."[42] At its root, the initial intent was not to save cost, but to improve planning efficiency. JIGSAW generated an improvement of 800% in planning speed while reducing the amount of personnel by half.[43] It was a product built in support of a military problem that had no alternative solution on the commercial market.

It is also important to clarify that a large organization such as the CAF can establish multiple digital factories supporting different objectives. The Canadian Army, the Royal Canadian Navy, the Royal Canadian Air Force, and CANSOFCOM all have different problems that require their own strategy and lines of effort. For example, the United States Air Force has a Software Ecosystem with more than 17 different initiatives.[44] Figure 1.1 shows a map of the various teams across the United States.

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[40] *Ibid*, 53.

[41] United States Air Force, "Product Line," last accessed 01 May 2022, https://kesselrun.af.mil/product-lines/OpsC2.html#weapon-system

[42] *Ibid.*

[43] *Ibid.*

[44] United State Air Force, "Software Factories", last accessed 01 May 2022. https://software.af.mil/software-factories/

Figure 1.1 – United States Air Force Software Ecosystem across the US

The counterargument against insourcing is the potential increase in risk for project delivery and sustainability.[45] Two main factors in this risk are the difficulties related to attracting the proper talent and expertise into the organization, and the additional need for resources and infrastructure to enable such endeavours.[46] For many companies, the digital factory becomes a brand and serves as a recruiting and talent management tool.[47] Moreover, with the increased availability of cloud-based services and DevSecOps tooling, implementing modern software development practices requires fewer resources compared to on-premises IT infrastructure. Additionally, with the increased availability of open-

[45] Nitin Naik. "Crowdsourcing, Open-Sourcing, Outsourcing and Insourcing Software Development: A Comparative Analysis."IEEE, 2016, 381. https://go.exlibris.link/cBHYVWtF.

[46] *Ibid,* 381.

[47] Rohit Bhapkar., J. Dias, and B. Seitz. "How a digital factory can transform company culture.", Last modified 19 September 2017. https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/how-a-digital-factory-can-transform-company-culture

source software, insourcing becomes a cheaper opportunity for organizations to develop their own digital products.

Complex projects such as modernization of aerial or vehicle platforms will be outsourced; however, a significant number of digitization and digitalization initiatives have a lower level of complexity, whereby they can be insourced to internal development teams. These teams choose an approach either to build software from scratch or to integrate commercial-off-the-shelf (COTS) technologies to the existing software infrastructure. Buying COTS is essential in cases in which a product already exists and would be too costly to replicate. Insourcing becomes relevant when the expertise required to make a relevant product is unique to internal business expertise.

As explained by the Chief Data Officer (CDO) of the US Army Futures Command (AFC), developing simple and mission-specific software will change the way we think about insourcing and outsourcing.[48] New metrics for determining if development should be insourced need to be based on the availability of user-feedback, how quickly the new capability can be delivered, and if it can integrate continuously with current mission-specific software.[49] For example, office productivity software, such as MS Teams, has access to a pool of users that is worldwide, which makes the creation of similar in-house software unnecessary and unviable.[50] The development of a fuel tanker planning tool software (JIGSAW) by KR is a good demonstration of a highly specific military need in which user feedback can only be accessible within the organization. The GAP also approaches outsourcing for problems of complexity that are beyond the ability of their

[48] Army Future Command Chief Data Officer, MS Teams interview with author, 21 Feb 2022.
[49] *Ibid.*
[50] *Ibid.*

internal team to develop and deploy under a certain time threshold.[51] In these cases, they outsource the challenge to research organizations, universities, and hackathons. These types of problems are those that require no immediate short-term fix, nor demand an immediate solution.

Finally, the organizational structure of the digital factory will depend on the digital transformation strategy, the various lines of efforts, the size of the organization it must support, and the type of technology it sustains. This paper provides a proposed structure in Chapter 4.

Understanding the Fundamentals

Being familiar with the key technological concepts is fundamental to understanding how the digital factory should be structured. One of the struggles observed by implementers of digital programs is the lack of technical understanding by leadership and middle managers. Translating strategy into technical actions is difficult and requires an ability to understand the business context and apply data and technology to it.

Much confusion relating to digital transformation stems from the misuse of terminology and concepts, especially concerning emerging technologies related to data analytics, artificial intelligence, big data, and cloud computing. Demystifying these concepts is necessary to enable the organization to embrace digitalization and to enable a higher level of trust in human-machine interactions.[52] Understanding these concepts are

[51] Former Global Analytics Platform Director, MS Teams interview with author, 19 January 2022.

[52] Chris Thatcher, "Artificial Intelligence: Overcoming the barriers to adoption," *Canadian Army Today,* 02 April 2022. https://canadianarmytoday.com/artificial-intelligence-overcoming-the-barriers-to-adoption/

also necessary to protect the organization from temporary hype and misrepresentation of third-party products.

Data Analytics for Decision Making

One of the most discussed emerging fields within digital transformation is the ability to execute data-driven decision-making via the use of data analytics. Data analytics is the human ability to conduct an analytical decision-making process leveraging data at its disposal. In its simplest form, "It is using data to gain insight or drive action."[53]

Data Analytics is categorized into three levels of proficiency: (1) descriptive analytics, (2) predictive analytics, and (3) prescriptive analytics.

Descriptive Analytics is the process of leveraging descriptive statistics and visualization methods to understand and gain insight from historical data. This type of analytics transforms raw data into an intelligible context to understand what happened.[54] Descriptive analytics also includes diagnostic analytics, which tries to understand why something happened.[55] Both methods are commonly employed by the discipline of Business Intelligence (BI) in which the main purpose is to understand the current situation within an organization in order to drive decision-making. However, these methods are limited since they focus only on explaining what happened in the past. Using the stock market as an example, past events will not guarantee future outcomes. In a military scenario, descriptive analytics can be used to answer the question, "how much ammunition did we spend in the last five years." Diagnostic analytics would try to answer the question,

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[53] Keith Rogers and A. Scott, *From Data to Insight: A Concise Guide to Practical Analytics*. (Kingston, 2020)

[54] *Ibid*

[55] Thomas Maydon, "The 4 Types of Data Analytics", *KD Nuggests* (Blog), last modified 04 July 2017, https://www.kdnuggets.com/2017/07/4-types-data-analytics.html

"why did we spend less ammunition this year compared to previous years?" Although we can find the right answer, we are asking the wrong question from a business decision standpoint. A better question is "how much ammunition will I expend next year?"

Predictive Analytics is the process of leveraging mathematical models to predict future value based on past data. These mathematical models can be built from statistical equations or via machine learning techniques such as regression, decision trees, and neural networks.[56] In the ammunition consumption example, predictive analytics would try to answer the question, "how much ammunition could I expend next year". The forecast will provide a good estimate on the demand for ammunition, but it is unlikely that this estimate will be exact. Moreover, buying a quantity based on the forecasted demand for ammunition may not be an optimal choice. Therefore, the question that should be asked in this case is "how much ammunition should I buy?"

Prescriptive Analytics. Prescriptive analytics is the process of estimating the most optimal option based on the probability of an event happening. This type of analytics leverages output from both descriptive and predictive analytics, and uses techniques such as Monte Carlo simulation to identify the most probable outcomes.

Moreover, what provides improved decision-making is the ability to build a model that leverages a perceived probability of something happening. It enables us to leverage factors that are not yet measured.[57] It can also be based on expected value in the future that we do not yet know, but that we can estimate based on our understanding of a situation. In

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[56] *Ibid*.

[57] Catherine Cote, "What is Prescriptive Analytics? 6 Examples," *Harvard Business School Online,* last updated 02 Nov 2021. *https*://online.hbs.edu/blog/post/prescriptive-analytics#:~:text=Prescriptive%20analytics%20is%20the%20process,data%2Ddriven%20decision%2Dmaking.

other words, it can make recommendations for decision-making based on the current comprehension of the future; however, it does not remove human discernment from the equation.[58] In the ammunition example, one could state that future consumption cannot be predicted without knowing if the CAF will be operating in a new theatre next year. Prescriptive analytics can factor the commander's perception of the geopolitical environment as a variable, thus revealing the estimated optimal quantity based on perceived risk. The model can be further adjusted as more fidelity is gained in the understanding of future conditions.

Data Analytics Specialties.

There are sub-specialties within data analytics that can be tailored to varied business domains; however, the fundamental concepts underlying these sub-specialties remain the same. What will change is the business context and the techniques used to solve different types of problems. Common subspecialties are:

- Business Analytics – Analytics for the purposes of improving the business operations and processes.
- Supply Chain Analytics – Analytics for the purpose of leveraging data and optimizing the activities across the supply chain process. It includes applications such as "supply chain execution, systems for procurement, inventory management, order management, warehouse management and fulfillment, and transportation

[58] *Ibid*

management (including shipping)".[59] In the CAF, most of these functions are done within the SAP software suite.

- People Analytics – This is "the practice of collecting and transforming HR and organizational data into actionable insight".[60] It supports decision-making for recruitment, retention, and talent management.

- Finance Analytics – Analytics for the purpose of forecasting and optimizing financial risk, volatility, and arbitrage. This is especially used within the banking and insurance industry.

- Pricing Analytics – Analytics for the purpose of conducting revenue management and pricing optimization. An example of pricing optimization is the use of dynamic pricing in the hotel and airline industry.

- Marketing Analytics – "The study of data to evaluate the performance of a marketing activity". [61] It uses analytics for the purpose of identifying and targeting customer segments to find opportunities and optimize profit.

- Text Analytics – Also known as text mining, this type of analytics "is the process of distilling actionable insights from text".[62] Through basic statistical analysis and

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[59] Ian McCue, "Supply Chain Analytics: What It Is & Why It Matters," *Oracle NetSuite, Educational Ressources,* last updated 16 December 2020. https://www.netsuite.com/portal/resource/articles/erp/supply-chain-analytics.shtml#:~:text=Supply%20chain%20analytics%20is%20the,transportation%20management%20(including%20shipping).

[60] Zack Johnson, "What is People Analytics and How do I Get Started" , *Vizier* (blog), last accessed 02 Mai 2022, https://www.visier.com/blog/technology/what-is-people-analytics-and-how-do-i-get-started/

[61] SAS, "Marketing Analytics", last accessed 02 May 2022, https://www.sas.com/en_ca/insights/marketing/marketing-analytics.html#:~:text=Marketing%20analytics%20is%20the%20study,optimize%20their%20return%20on%20investment.

[62] Kwartler, Ted. *Text mining in practice with R*. John Wiley & Sons, 2017: 2.

> natural language processing (NLP) techniques, a data analytics practitioner will attempt to understand trends and context out of the pool of data at its disposal. Text analytics is a growing field as it supports digitization (transcripting analog to digital), the extraction of insight from social media (such as sentiment and polarity analysis), and the identification of patterns in text that would not otherwise be feasible at scale. In the military, text analytics is one of the most impactful analytics sub-specialties, especially in the context of intelligence processing.

The list continues; therefore, leaders must remain vigilant to not fall for tailored marketing tactics of selling "government" or "military" solutions when all that is required is to use data analytics techniques and methodologies within the appropriate (i.e., military) context.

Data Science

Data analytics is supported by data science process and techniques. IBM defines data science as a "multidisciplinary approach to extracting actionable insights from the large and ever-increasing volumes of data collected and created by today's organizations", and includes the acquisition, processing, and analysis of data, along with the presentation of insight gathered from it.[63] Scott and Rogers identify data science as a process in six steps, from defining a problem to operationalizing insight into actions.[64]

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[63] IBM, "What is Data Science." *IBM Cloud Education*, last modified 15 May 2020, https://www.ibm.com/cloud/learn/data-science-introduction

[64] Keith Rogers and A. Scott, *From Data to Insight: A Concise Guide to Practical Analytics*. (Kingston, 2020)

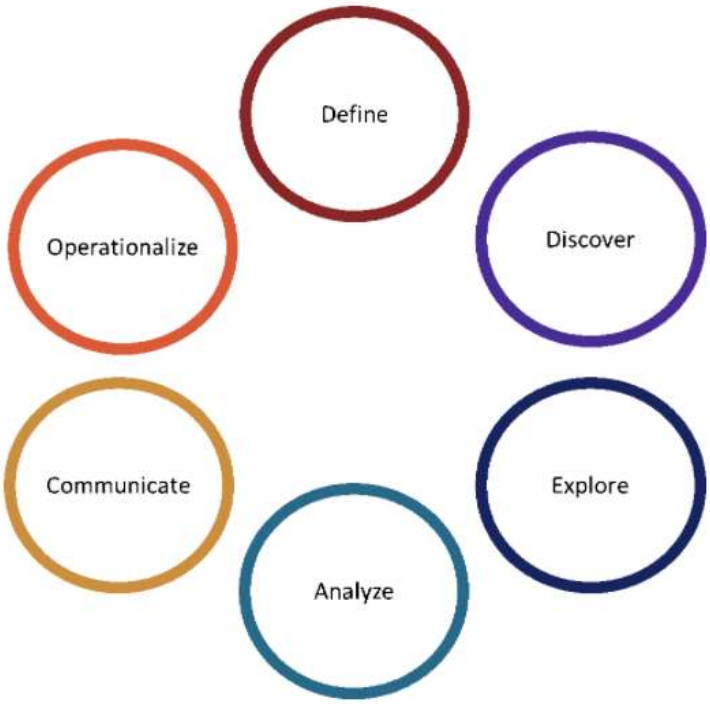

Figure 1.2 – The Data Science Process proposed by Scott and Rogers.

Define refers to problem and decision identification. Defining the problem means understanding the business problem and identifying the decision that we are trying to make, and must focus on providing value.[65] This happens in tight collaboration with the stakeholder and is difficult to get right. Poor definition often leads to misalignment in the analysis and limits the potential of quality decision-making. For example, under GradA, managers at the directorate level were driven to integrate data analytics tools to support their decision-making. Unfortunately, they were often drawn into focusing on understanding the details within the data rather than in determining the type of decision they sought to make. Projects that focused on decision-making had increased output value compared to those that focused solely on data aggregation. The *define* step must be enabled

[65] *Ibid*.

by operationally-focused product managers or analytics practitioners that can translate decision-making needs into the data science process.

Discover. This step refers to the identification, cleaning, and transformation of the data into a form that can be leveraged for descriptive analysis and/or fed into machine learning models.[66] This process uses techniques of data engineering as well as data science. It is often referred to as data preparation. This step addresses the type of information that is required to make the right decision and the process of finding where and how to get the data.

Explore and analyze. These two steps are often what people perceive as the essence of data science. They are the use of descriptive analytics techniques to understand and visualize the data, and the use of machine learning techniques to build models to forecast and predict future values that could support the decision-making process.[67] These steps enable the ability to answer the business questions identified as part of the *define* step.[68]

Communicate and operationalize. If a data science project is not communicated back to leadership and integrated as part of the decision-making process, it is pointless. *Communicate* refers to the ability to explain and distribute the insight gathered from the process. *Operationalization* refers to the integration of the technical and business output of the data science project.[69] Effective data-driven organizations enable the automated collection, processing, modelling, and output of the data in a way that constantly feeds decision-making.

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[66] Keith Rogers and A. Scott, *From Data to Insight: A Concise Guide to Practical Analytics*. (Kingston, 2020)

[67] *Ibid.*

[68] *Ibid.*

[69] *Ibid.*

Artificial Intelligence.

AI is defined by McKinsey & Company as "the ability of a machine to perform cognitive functions we associate with human minds, such as perceiving, reasoning, learning, interacting with the environment, problem solving, and even exercising creativity."[70] Dr Stephen Thomas provides a simpler definition of AI as "a computer's ability to make decisions or to predict."[71] It is important to keep in mind that AI is not defined by its ability to make the "right" decision or prediction; therefore, a "dumb" AI is still considered AI. Often, people think of AI as the android or killer robot that moves, sees, learns, talks, and makes rational decisions on its own; however, to be able to arrive at such a level of proficiency, it will need complete mastery across the six main disciplines of AI.[72]

Natural Language Processing (NLP) – "Reveal[s] the structure and meaning of text."[73] NLP is used for chatbots, document classification, sentiment analysis, machine translation, Optical Caracther Recognition (OCR), document summarization, and other use cases utilizing text. Some of the best-known applications of NLP are the AI assistants such as Siri and Alexa. One of the most powerful NLP models is named GPT-3[74], which is of such high quality that some researchers "claimed that GPT-3 can even generate news articles which human evaluators have difficulty distinguishing from articles written by humans."[75]

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[70] QuantumBlack AI by McKinsey, "An executive's guide to AI," last updated 2020, https://www.mckinsey.com/business-functions/mckinsey-analytics/our-insights/an-executives-guide-to-ai

[71] "7 Things Every Business Leader Should Know About Artificial Intelligence", YouTube video, 4:43, posted by Smith School of Business," 22 Jan 2021, https://youtu.be/06v9LMXHgyI

[72] Stuart Russell, and P. Norvig. Artificial Intelligence: A Modern Approach. (Upper Saddle River, NJ: Pearson Education, Inc, 2010), 2-3.

[73] Google Cloud, "What is Natural Language Processing?", Last accessed 02 May 2022, https://cloud.google.com/learn/what-is-natural-language-processing

[74] Open AI, "Overview", last accessed 02 May 2022, https://openai.com/

[75] Ram Sagar, "OpenAI Releases GPT-3, The Largest Model So Far,", *AIM*, last modified 03 June 2020, https://analyticsindiamag.com/open-ai-gpt-3-language-model/

Knowledge Representation – This discipline refers to the ability to "encode human knowledge and reasoning into a symbolic language that enables it to be processed by information systems", and "It is responsible for representing information about the real world so that a computer can understand and can utilize this knowledge to solve complex real-world problems." [76] Knowledge representation includes the ability to infer new information from old information.[77]

Automated Reasoning - This domain, combined with knowledge representation, is associated in popular culture with what is considered "true" AI. Automated reasoning is the ability to "use the stored information to answer questions and to draw new conclusions."[78]

Machine Learning – It is defined as "the science (and art) of programming computers so they can learn from data."[79] Machine learning "uses large amounts of data and produces mathematical models"[80] to "detect and extrapolate patterns."[81] Within data analytics, machine learning techniques are used extensively to predict and forecast value based on past data and are at the foundation of most AI algorithms. Machine learning is categorized in three types: supervised, unsupervised, and reinforcement learning.

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[76] Saif Uddin, "Knowledge Representation and Reasoning: Chapter 1- Basic Gyaan about Knowledge Representation," *Medium* (blog), last modified 30 Dec 2019, https://mdsaife245.medium.com/knowledge-representation-and-reasoning-chapter-1-basic-gyaan-about-knowledge-representation-7630fdaa5a53

[77] Stuart Russell, and P. Norvig. Artificial Intelligence: A Modern Approach . . ., 235.

[78] Stuart Russell, and P. Norvig. Artificial Intelligence: A Modern Approach . . ., 2

[79] Géron, Aurélien. *Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems*. " O'Reilly Media, Inc.", 2019: 10.

[80] Keith Rogers and A. Scott, *From Data to Insight: A Concise Guide to Practical Analytics*. (Kingston, 2020)

[81] Stuart Russell, and P. Norvig. Artificial Intelligence: A Modern Approche . . ., 2

Supervised Learning[82]– This method's objective is to predict or classify data based on an already labelled dataset. It is a technique that leverages both the input and output of a dataset to generate a model.[83] Examples of models are regression, decision trees, random forests, neural networks, and many others. In a banking sector example, a supervised learning model can predict if an individual applying for a loan is likely to default based on various variables. Using the previous data of customers who have defaulted or not, a model is created from relevant variables available within the dataset. Then, every new applicant applying for a loan will be compared to the model which will result in a target value (to default or not default).

Unsupervised Learning[84]– This method's objective is to find patterns within an unlabeled dataset "without the need for human intervention".[85] Humans can identify patterns across two or three variables but are highly inefficient at finding patterns across dozens of them. This is where unsupervised learning becomes handy. Unsupervised learning is used for clustering analysis, recommender systems, and association problems.[86] Examples of unsupervised learning are the identification of customer purchase behaviour, recommendations on likely associations from items within a cart, and fraud detection based on abnormal transactions in comparison to legitimate ones.

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[82] IBM Education, "What is Machine Learning," *IBM Cloud Learn Hub,* last modified 15 July 2020, https://www.ibm.com/cloud/learn/machine-learning

[83] Keith Rogers and A. Scott, *From Data to Insight: A Concise Guide to Practical Analytics*. (Kingston, 2020)

[84] *Ibid.*

[85] *Ibid.*

[86] Meghan Rimol, "Understand 3 key Types of Machine Learning," *Gartner* Insights, last modified 18 March 2020, https://www.gartner.com/smarterwithgartner/understand-3-key-types-of-machine-learning

Reinforcement Learning[87] – Reinforcement learning is a "model that learns as it goes"[88] from its environment and is given feedback by a system of rewards when it arrives at the right solution. Feedback can be given by a system of points, or via human feedback. One of the most impressive examples of reinforcement learning is the OpenAI game of *Hide and Seek* in which two AI agents compete to earn the most points. The competing agents, over-time, used "sophisticated tools and coordination" to "build multi-object shelters with moveable boxes, which in turn, leads to agents discovering that they can overcome obstacles using ramps".[89] The evolution of the behaviors of the agents as their physical environment changes demonstrates the power and potential of reinforcement learning algorithms.

Computer Vision (CV). CV is the ability to extract information and insight from digital images, videos, and other types of imagery sensors.[90] CV is used in security (i.e., facial recognition and entity extraction), self-driving cars, and medical imaging. CV tasks include image classification, object detection and tracking, and content-based image retrieval (i.e., reverse image search).[91] This field of AI will be used extensively within the ISR domain as it will enable the automatic identification of entities from various type of sensors. This technology will be a force multiplier for imagery analysts as it will enable a computer to

[87] IBM Education, "What is Machine Learning," *IBM Cloud Learn Hub,* last modified 15 July 2020, https://www.ibm.com/cloud/learn/machine-learning

[88] *Ibid.*

[89] Bowen Baker, and al. "Emergent tool use from multi-agent autocurricula." *arXiv preprint arXiv:1909.07528* (2019): 1-4

[90] IBM Education, "What is Computer Vision?," *IBM Cloud Learn Hub,* last modified 15 July 2020, https://www.ibm.com/topics/computer-vision

[91] *Ibid*.

conduct initial parsing of vast amounts of video feed data and prioritize those requiring human involvement.[92]

Robotics – AI in robotics is the intersection of automated robotic systems (such as those in assembling factories) and autonomous and flexible algorithms that learn from sensory inputs.[93] For example, AI robotics looks at transitioning from a remote-controlled car to a self-driving car.

Unfortunately, AI does not automatically mean relevant. The algorithms are dependent on high quality data and the AI is only as good as the data that is used to train it. In other words, "garbage in, garbage out". Its effectiveness is also dependent on the volume of data available to train the model. In general, the more data available, the better the potential to create a valuable model. However, a low volume of high-quality data will supersede a high volume of poor-quality data.[94] Moreover, the quality of the AI model will depend on the parameters and variables that are used. This is where the roles of the data scientist and AI engineer become valuable; however, as AI becomes more mainstream, there will be a lesser need for organizations to build their own AI models. Even today, very powerful models are accessible as "plug and play" and require minimal fine-tuning to achieve decent results. Companies such as Microsoft, Amazon, and Google offer powerful AI services that are easily accessible through their cloud platform. In fact, Andrew Ng, one of the most prominent figures in the AI field, argues that some of the AI systems are so well-developed

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[92] Berenice Baker, "Mind's Eye: Visualization Intelligence Takes to the Battlefield," *AirForce Technology,* last modified 22 June 2011. https://www.airforce-technology.com/analysis/feature122432/

[93] "Ethics of Artificial Intelligence and Robotics", *Stanford Encyclopedia of Philosophy*, 30 Apr 2020, https://plato.stanford.edu/entries/ethics-ai/#AIRobo

[94] Eliza Strickland, "Andrew NG: Unbiggen AI", *IEEE Spectrum,* last modified 09 Feb 2022, https://spectrum.ieee.org/andrew-ng-data-centric-ai

that the effectiveness of these algorithms is bottlenecked by the quality of data and its supporting architecture.[95] Hence, leaders of digital transformation must be careful to not push solely for the implementation of AI technologies. Success will be dependent on the prioritization and investment in data architecture and data engineering efforts. Moreover, not every problem requires an AI solution.

Data and Data Engineering

Data is at the foundation of every digital transformation, such that many refer to it as the new "gold" or as the most valuable resource.[96] Especially with the arrival of social media, Internet of Things (IoT), and the widespread integration of sensors, the volume of data generated every year is estimated to compound at a rate of 19%.[97] In 2021, it was estimated that the world generated more than 29 Zetabytes of data and is forecasted to increase to 181 Zetabytes by 2025.[98] To put this scale in perspective, a Zetabyte(ZB) is equal to a billion terabytes (TB). A TB is equivalent to about 250,000 photos or 500 hours of HD video.[99] In fact, data generated across the world is so immense that the term Big Data has emerged, defined as a "large set of data that is almost impossible to manage and process using traditional business intelligence tools."[100]

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[95] *Ibid*.

[96] Economist, The. "The world's most valuable resource is no longer oil, but data." *The Economist: New York, NY, USA* (2017). https://www.economist.com/leaders/2017/05/06/the-worlds-most-valuable-resource-is-no-longer-oil-but-data

[97] Holst, Arne. "Volume of data/information created, captured, copied, and consumed worldwide from 2010 to 2025." *Statista, June* (2021).

[98] *Ibid.*

[99] "How much is 1 TB of storage?," *Dropbox (*blog), last accessed 02 May 2020. https://experience.dropbox.com/resources/how-much-is-1tb#:~:text=1%20TB%20gives%20you%20the,files%2C%20PDFs%2C%20and%20presentations.

[100] Mark van Rijmenam, "A Short History of Big Data", *DataFlow: Data & Technology* Insights (blog), last modified 7 January 2013. https://datafloq.com/read/big-data-history/

The volume is so immense that "investing in AI" is unachievable unless more efforts are dedicated to improving data collection, storage, processing, and presentation. Data architecture is so foundational that it is an absolute prerequisite to achieve proficiency in AI and to achieve digital transformation. Monica Rogati argues "that most companies are not ready for AI" because they lack the means to collect data and lack proper data infrastructure.[101] To become data-centric, an organization needs to meet some of the basic needs within the "data science hierarchy of need".[102] Data-centricity requires investment in talent, tools, equipment, and the technologies to enable data science and data operations.

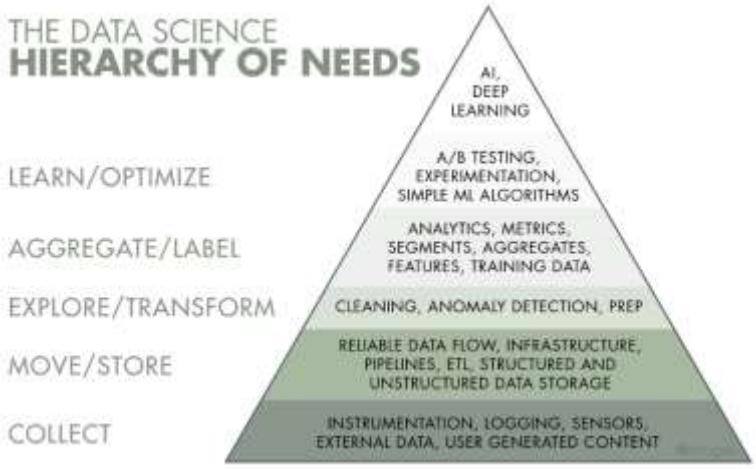

Figure 1.3 – Data science hierarchy of needs.[103]

The term data operations involve five stages – *Capture, Store, Transform, Publish* and *Consume.*[104] *Capture* is the collection of data which can be done in batches (via other systems or through applications) or via streaming (events of data in real-time). *Store* is self-

[101] Monica Rogati, "The Data Hierarchy of Needs," *Hackernoon,* last modified 12 June 2017, *https*://hackernoon.com/the-ai-hierarchy-of-needs-18f111fcc007

[102] *Ibid.*

[103] *Ibid.*

[104] Charlie Crocker, "The Guide To Understanding Cloud Data Services in 2022," *Unravel Data*, last accessed 02 May 2020, https://www.unraveldata.com/understanding-cloud-data-services/

explanatory, the location where the data will reside in its structured (tables of columns and rows) or in unstructured format (video, images, text). *Transform* refers to the manipulations performed to make the data more valuable. Transform is specific to the steps of "clean, prepare, and transform" through manipulation or algorithm.[105] Transformation also includes the output of AI techniques that augments the data with even more data.

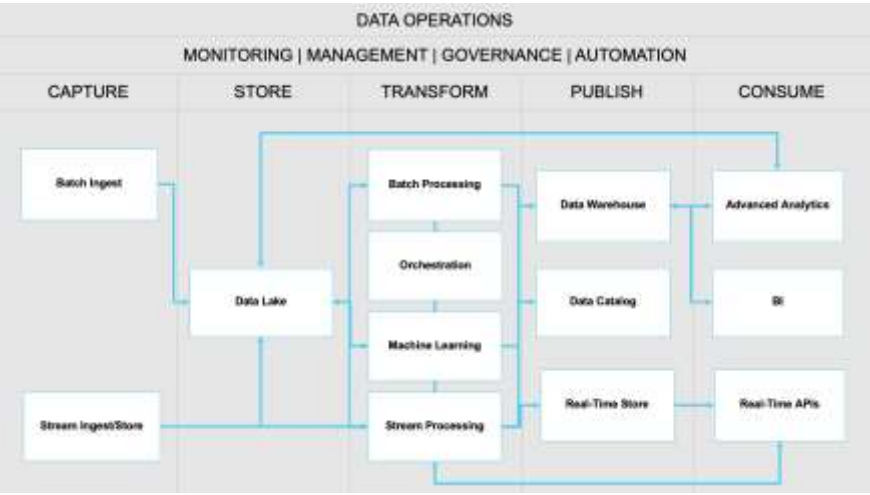

Figure 2.4 – Data Architecture Logical Component[106]

Publish(ing) makes data findable and accessible to the consumer. Consumers can be humans or software applications. Finally, *Consume* is the final stage of presenting the data into the applications that will enable system to interact with users. The process of extracting, transforming, and loading (ETL) data from the source to a presentation layer is named ETL pipelining. The overarching discipline that is responsible for ETL is named Data Engineering. In Rogati's Data Science hierarchy of needs, data engineering is responsible for the collection, moving/storing, and exploration/transformation of the data.

[105] *Ibid.*
[106] *Ibid*

Data architecture becomes a challenge when it passes the threshold to *Big Data*; although the threshold can be subjective and depends on an organization's ability to collect, store, and process the data at its disposal for a specific problem. For example, managing all CAF C4ISR platform data can be considered a big data problem for the organization, but may not be from Netflix's point of view. It all depends on the infrastructure, technical skillset within the workforce, and the consumer's ability to process such information.

Big data is a specialty as it requires expertise in data architecture, IT infrastructure, data storage, data processing, and the analytics know-how to extract business insight. Big data is described by five characteristics:[107]

- Volume - The size of data to be stored, processed, and analyzed.
- Velocity - The speed at which the data must be processed through the network. This is especially important when conducting real-time decision making or analysis.
- Variety – This is related to the type of data to be stored and processed such as images, social media feeds, transactions etc.
- Veracity – This relates to the accuracy of the data.
- Value – This relates to the business value gained out of the data being collected. Data must be relevant to extract insight from it.

In a military context, the intelligence community battles with a volume of data that is beyond its ability to process. Integration of data sources into one coherent architecture is a significant challenge, especially when data resides across various organizations in

[107] Terradata, "What are the 5 V's of Big Data?", last accessed 02 May 2022, https://www.teradata.com/Glossary/What-are-the-5-V-s-of-Big-Data

siloed systems. Information is hidden in text-based reports, in satellite imagery, in Signals Intelligence (SIGINT) databases, in video feeds from ISR platforms, and across the open-source internet. Military operations have a data integration problem, such as having the right data at the right time at the right place get situational awareness.

Across the different military digital factories, every team invested heavily into the resourcing and staffing of data engineering teams and into data architecture. For example, GradA invested in a complete modernization of the data architecture to enable data analytics at scale, but also to develop a data-centric design that could bridge the interoperability gap between any software and data repository. Every new web-app, custom-built software, and third-party solution must leverage this data architecture to store and present its information. The same approach was used by the GAP, standing up a data pipeline team to build a data architecture and manage all data flows across the infrastructure.[108] This also provides better control on the movement of data, and ensures that the organisation does not become dependent on third-party tools and suffer from vendor lock-in. Vendor lock-in happens when the data can only be manipulated and viewed in a coherent manner through a unique third-party application.

For many, the software application and its data are seen as one entity or as one package that cannot be dissociated. This leads to the misconception that the use of specific tools must be mandated across the organisation to centralize and standardize data collection. This is a profound mistake in understanding. The software and data must be seen as two separate entities. For every application (front-end), there is a database supporting it (back-end). The database allows for the collection and storage of information

[108] Former Global Analytics Platform Director, MS Teams interview with author, 19 January 2022.

made through the application whereas the front-end serves as the interaction interface with the user. This dissociation is, in the opinion of the AFC CDO, a significant milestone for an organisation as it changes the approach to development, procurement, and policy.[109]

Cloud Computing

Big data implies scalability and companies achieve scalability using cloud computing. Cloud computing is defined by Microsoft as the "delivery of computing services – including servers, storage, databases, networking, software analytics, and intelligence - over the Internet ("cloud")".[110] In other words, it is the outsourcing of the IT infrastructure, services, and applications to a third-party instead of managing it internally. Cloud architectures are categorized into three types. First, *Public cloud* is associated with the cloud services provided by a cloud provider and is accessible via the internet. *Private cloud* refers to an infrastructure that is used solely by one organization, and is either outsourced into a third-party data center, or insourced to an on-premises data center; most of DND's infrastructure is considered a private cloud. There are also *hybrid clouds*, which are a combination of both infrastructure and services operating in the public cloud and on-premises infrastructure. Hybrid clouds are popular in large enterprises that need the flexibility and scalability of cloud services, but still want to maintain control and security of their data on an on-premises infrastructure.

Cloud providers have various types of services depending on the organisation's control and management requirements. As identified in figure 2.5, the various types of

[109] Army Future Command Chief Data Officer, MS Teams interview with author, 21 Feb 2022.

[110] Microsoft Azure, "What is cloud computing? A beginner's guide,", last accessed 05 May 2022. https://azure.microsoft.com/en-us/overview/what-is-cloud-computing/#cloud-deployment-types

services will have varying distribution of responsibility between the client (light blue) and the third-party cloud provider (dark blue).[111]

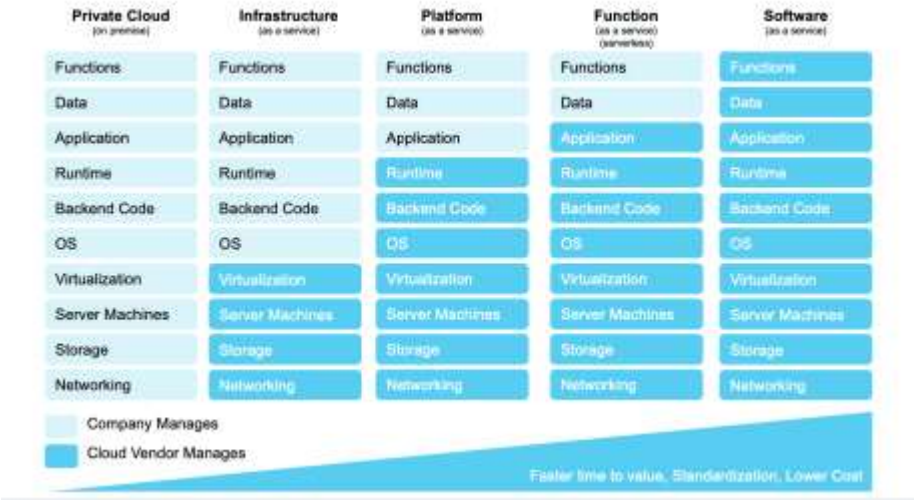

Figure 2.5 – Support responsibility across cloud services.

On Premise	Infrastructure as a Service	Platform as a Service	Function as a Service	Software as a Service
Data Operations	Data Operations	Data Operations	Data Operations	Data Operations
Data Engineers	Data Engineers	Data Engineers	Data Engineers	Data Engineers
Pipeline Engineers	Pipeline Engineers	Pipeline Engineers	Pipeline Engineers	
Solution Engineers	Solution Engineers	Solution Engineers		
Infra Engineers	Infra Engineers			
HW/NW Engineers				

Figure 2.6 – Cloud Services and Resource Requirements [112]

The benefits of cloud computing are that outsourcing data centres and related services enable organizations to prioritize the development of new products, augment the efficiency of managing infrastructure and services, and reduce physical infrastructure

[111] Charlie Crocker, "The Guide To Understanding Cloud Data Services in 2022," *Unravel Data*, last accessed 02 May 2020, https://www.unraveldata.com/understanding-cloud-data-services/

[112] https://www.unraveldata.com/wp-content/uploads/2019/05/02_Screen-Shot.png

costs.[113] Moreover, cloud computing enables small organizations to build, implement, and deploy IT infrastructure within a fraction of the time that it would take to implement their own data centre. Therefore, cloud offerings remove the entry barriers of creating new products and reduce upfront infrastructure capital costs.[114]

Cloud computing is critical in the support of digital factories as it enables increased collaboration with outside organizations. As public clouds are accessible through the Internet, it enables an organization to store and share releasable data that can be used by a third party (such as academia) to conduct research and development. The cloud environment provides the framework and the tooling required to implement DevSecOps practices with remote and decentralized teams.

For the digital factory, cloud services enable two key functions: (1) IT and data architecture to support unclassified data analytics, and (2) provide DevSecOps platforms to accelerate software development. Within on-premises infrastructure, implementing DevSecOps tooling and processes require a *platform team* that dedicates personnel to install, configure, manage, and support the various applications. Moreover, all the services are dependent on the availability of IT infrastructure, which can become the biggest bottleneck to supporting rapid development and deployment of new software applications. The arrival of cloud services enables a large organization to implement a cloud based DevSecOps environment under a few clicks., without dedicated IT resources to support the platform. The flexibility and scalability of cloud infrastructure permit the deployment of the various tools required to build, test, and deploy code within a secure environment. It

[113] Luca Ferri, and al., "Cloud computing in high tech startups: evidence from a case study." Technology Analysis & Strategic Management 32, no. 2 (2020): 147

[114] *Ibid,* 148.

also enables streamlining Continuous Integration and Continuous Delivery outside of the operational or classified production systems.

The USAF implemented a successful approach to enterprise DevSecOps via the Platform One initiative. Platform One is a cloud environment with the appropriate DevSecOps services to support the software factories across the USAF and other military services. The architecture can be customized based on the needs of development teams while still following the policy and guidance provided under the DoD DevSecOps Enterprise Initiative.[115] It was also developed with the consideration that DoD should leverage open-source initiatives to reduce vendor lock-in.[116] Moreover, Platform One leverages established contracts with the main cloud providers such as Google Cloud Platform, Microsoft Azure, and Amazon Web Services to provide scalability, in both the unclassified and classified domains.

Unfortunately, in the GoC, the lack of a classified cloud offering obliges DND to continue its reliance on on-premises IT infrastructure for its classified network. Thus, DND will continue to be required to invest in on-premises IT infrastructure and platform teams to support the transition from cloud-based development into on-premises production systems.

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[115] United State Air Force, "Platform One", last accessed 01 May 2022. https://software.af.mil/team/platformone/

[116] "DoD Enterprise DevSecOps Initiative and Platform One", Platform One website, posted by the Office of the Chief Software Officer, 2:24. last accessed 01 May 2022, https://software.af.mil/team/platformone/

CHAPTER 2: STRATEGIC ENABLEMENT

We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten. Don't' let yourself be lulled into inaction

— Bill Gates

This chapter will explore the topics and concepts that are specific to the strategic thinking of digital transformation. As experienced by the author, digital factories are implemented by innovative teams, but it all starts with strong strategic enablement from the wider organization. This essay defines strategic enablement as the various conditions required for a digital factory to achieve sustainable success in the long-term. It is categorized in three components: (1) clear and succinct strategy, (2) a deliberate plan to accelerate change, and (3) the creation of a dual operating system.

Strategy

It is important to differentiate the strategy overseeing the digital transformation versus the one for the digital factory. The digital transformation strategy will focus on the overall modernization of the organization, whereas the digital factory's strategy will focus on accelerating value production by providing the relevant guiding principles to development efforts. As Chamorro-Premzuic argues, "[t]rue innovation is unlikely to occur in the absence of a meaningful mission or clear long-term vision."[117] So, even with appropriate conditions (funding, resourcing, innovative personnel, and the proper

[117] Thomas Chamorro-Premuzic, 2013. The five characteristics of successful innovators. Harvard Business Review, 5.

organizational structure), a digital factory requires the right combination of strategy, vision, and execution.

Strategy can mean everything and nothing at the same time. Elspeth Murray provides a simplified version of strategy to her entrepreneurship students. She proposes that strategy is all about choices.[118] The choices on the types of customer segment. The choices on the types of products that will be developed. The choices on the types of approach, capabilities, and technologies that will be needed to "win."[119]

These series of choices will define the business model, the sequencing, and the type of actions and activities that will compose the game plan.[120] Moreover, the strategy will be supported by the vision, mission, and values.[121]

Murray defines vision as the picture of what an organization aspires to become in the future.[122] It must be compelling and act as a "north star" to guide the team's effort in moments of doubt.[123] From an institutional standpoint, the vision should talk to the digital transformation aspiration and where the organization perceives itself in the next three to five years. This vision will be implemented through a strategic plan that will identify the objectives and the lines of effort to achieve it.[124] Some military leaders believe that "business strategic planning" poorly translates into the military context; but it is simply the "civilian" version of campaign planning. Nevertheless, the vision should provide clarity on

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[118] "Elspeth Murray, Strategy: Mission Purpose Vision Values", Vimeo video, 10:12. Posted by "Sindeyeve Matrix", 5 Nov 2020. https://vimeo.com/476096212

[119] *Ibid.*

[120] *Ibid.*

[121] *Ibid.*

[122] Elspeth J. Murray, and Peter R. Richardson. *Fast forward . . . ,* 66.

[123] *Ibid.*

[124] Elspeth J. Murray, and Peter R. Richardson. *Fast forward . . .* , 64-66.

what the organization wants to become, the scope of its activities, and how it wants to be perceived by its stakeholders.[125]

But the challenge doesn't lie only in the establishment of a vision, but how to translate it into tangible actions.[126] To achieve a vision, the organization must establish a mission and the key values the organization should abide by. Without these two, translating into a game plan that will guide focused and pertinent actions will be difficult.[127] Once again, military doctrine includes these concepts as part of campaign planning. It is to identify an end state (vision), provide the frame of what will be done and why (mission), and which lines of activities must be pursued to achieve these objectives (lines of effort).

What is a Good Strategy?

One of the most common mistakes in strategy building is to "fail to distinguish between operational effectiveness and strategy."[128] Operational effectiveness (OE) is defined by Porter as the "means of performing similar activities better than rivals perform them."[129] From a government perspective, it means to improve the conduct of activities in the future better than we did in the past. From a military perspective, it means doing things better than the adversary. Porter thinks that "constant improvement in operational effectiveness is necessary to achieve superior profitability" but does not allow it to outperform the competition.[130] OE reinforces a certain level of status quo. At some point, operational effectiveness reaches a plateau, where the energy and resources assigned to

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[125] Elspeth J. Murray, and Peter R. Richardson. *Fast forward* . . . , 65-66
[126] Elspeth J. Murray, and Peter R. Richardson. *Fast forward* . . . , 20
[127] Elspeth J. Murray, and Peter R. Richardson. *Fast forward* . . . , 65-67
[128] Porter, Michael E., "What is Strategy." Harvard Business Review, (November 1996): 1. https://hbr.org/1996/11/what-is-strategy
[129] *Ibid,* 3.
[130] *Ibid,* 4.

augment operational efficiency outweigh the benefits.[131] For governmental organizations, this is an easy trap. As governments do not focus on profit, it can use a measure of output in time or money saved instead. Government organizations tend to focus on improving the operational efficiency of activities that they already conduct without questioning if these activities are really what will set them apart. OE cannot be the strategy but only a potential objective that is part of that strategy.

Strategy Must be Unique and Targeted

A good strategy combines three concepts. First, it is "the creation of a unique and valuable position, involving a different set of activities".[132] This means that a set of activities can be identified that will provide inherent value to a pool of customers. It can either be by "serving broad needs of few customers", and "serving broad needs of many customs in a narrow market".[133] But in the end, it cannot solve everything for everyone. It must be deliberate and define clearly what problem will be solved for which customer, highlighting the core Customer Value Proposition (CVP). As an example, the US Army Software Factory identified their CVP as: "[w]e are increasing the digital proficiency across the Force and developing modern software solutions for Army Problems".[134] Their strategy is, therefore, to identify key Army problems that require custom and modern software solutions to be developed. Not any problem, but those that are simple enough that they can be developed and integrated faster than if they were outsourced to industry.[135]

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[131] *Ibid, 4*.
[132] *Ibid, 4*.
[133] *Ibid, 4*.
[134] U.S. Army Future Command, "Software Factory", last accessed 02 May 2020, https://armyfuturescommand.com/software-factory/
[135] Army Future Command Chief Data Officer, MS Teams interview with author, 21 Feb 2022.

Defining customers for governmental organizations is difficult in comparison to the private sector. With the latter, it targets the pool of customers that will provide the best revenue opportunity. If you can't provide value within a reasonable time, bankruptcy awaits you. On the other end, public sector organizations are somewhat immune to such faith. The natural selection of the capitalist market does not affect the government the same way. A governmental digital factory could produce low results and burn through money for years prior to being restructured or disbanded. Therefore, it is crucial that a digital factory leverage a framework to evaluate performance, such as those within the DevSecOps methodology (Chapter 3).

Strategy Must Make Trade-offs

The second concept of strategy is all about making trade-offs to compete; "[t]he essence of strategy is choosing deliberately what *not* to do".[136] Otherwise, "[w]ithout trade-offs, there would be no need for choices and thus no need for strategy."[137] Within the government, the threat of competition is different than in the private sector, although the same concepts apply. If a competitor provides a unique service or provides the same service cheaper, they will win. Therefore, the rivals of the military digital factory are other enterprise software projects, other directorates, or industry itself. As proposed by Porter, "competitive strategy is about being different" and "it means deliberately choosing a different set of activities to deliver a unique mix of value."[138]

The leadership of the digital factory must identify how it will remain unique in comparison to other similar initiatives. Outsiders and new leadership will regularly debate

[136] Porter, Michael E., "What is Strategy." . . ., 10.
[137] Porter, Michael E., "What is Strategy." . . ., 4.
[138] *Ibid, 4*.

the relevancy of a digital factory, proposing to outsource or centralize resources under other programs. This is especially the case when products duplicate ongoing projects, or if they do not deliver on value propositions. Hence, the type of activities that should be pursued must be either unique enough that no other departments or projects can replicate, or that they are so innovative that previous solutions will become obsolete.

Too many activities can dilute an organization's competitive edge and risk its long-term viability. One of the key dilemmas faced by the GradA leadership was to decide whether they should prioritize enterprise OE problems. Many organizations and initiatives across the CAF, especially within ADM(IM) and ADM(DIA), solely focus on enterprise-wide problems such as HR, supply chain management, and other types of enterprise issues. Applications solving enterprise problems under GradA had a significant edge in comparison to the tools provided by the CAF enterprise, in part because of their intuitiveness and their functionalities. Nevertheless, there were always doubts in their long-term viability, not because of the lack of quality or user adoption, but simply because of the perception of duplication. Product-solving OE are always vulnerable to departmental policy (i.e., mandating the use of a single software vs. another). This is in part the reason why the GAP decided to deliberately exclude "back-office functions" and focus solely on the SOF Operations and Intelligence communities.[139] Supporting Porter's approach to strategy, the deliberate withdrawal from enterprise functions (i.e., budget management, HR staffing, recruitment, and others) made the GAP's strategy less at risk of internal competition and interference.

[139] Former Global Analytics Platform Director, MS Teams interview with author, 19 January 2022.

Strategy must have alignment of activities.

Finally, Porter's third consideration is that strategy must "create a fit among a company's activity".[140] He argues that "the success of a strategy depends on doing many things well – not just a few - and integrating among them".[141] "If there is no fit among activities, there is no distinctive strategy and little sustainability".[142] If an activity is neither consistent, reinforcing, or integrated, an organization will most likely suffer misalignment in their unity of action.[143] So once again, our software factories' leadership must ensure that all activities undertaken by the teams support a line of effort and its associated objective.

Is a Strategy Required?

Strategy and business models are a highly controversial topic in the world of tech start-ups and innovation. Some advocate lengthy business plans and analyses to demonstrate feasibility of a venture while others favor a lean methodology to "act, improvise, and pivot."[144] The learn by doing approach, such as that indicated in the popular Lean Startup, "has been particularly effective in starting app-based businesses".[145] This model has been embraced by one of the most successful software companies, Apple. However, it is debated if the astronomical success from these companies can become a

[140] Porter, Michael E., "What is Strategy." . . ., 10-12.
[141] *Ibid,* 10-12.
[142] *Ibid,* 15.
[143] *Ibid,* 12.
[144] Greene, F. J., and Christian Hopp. "Research: Writing a business plan makes your startup more likely to succeed." Harvard Business Review (2017): 14.
[145] Carl Schramm, "It's not about the framework." Harvard Business Review 2018, no. May-June (2018): 12.

blueprint, as academic studies on the topic often use case studies instead of quantitative data.[146]

On the other hand, some studies determine that those who plan are more likely to achieve success. [147] A study has found that between similar start-ups, the ones that wrote formal plans were 16% more likely to achieve viability.[148] In an environment where the likelihood of success is below 25%, any additional chance of success makes a difference.[149] However, a complete strategy delivered too late is as irrelevant as a strategy that is so broad that no one knows how to implement it. Unfortunately, it is too often utilized as a precondition to initiate action. Risk-averse executives and managers will wait for in-depth strategy documents and robust governance frameworks to be written prior to committing resources and funding to digital transformation initiatives.

A balanced approach to strategy lies in the sequencing between action and strategic planning. Strategy documents don't have to be long, nor do they have to be complete. Strategy must be refined iteratively based on the feedback received by the customers and based on the changes within the landscape in which the organization operates.[150] Problems evolve and plans must adapt.

Strategy and governance have a time and place but are dependent on the comprehension of the environment and the problems to be solved.[151] As stated by the former GAP director, "You need something to govern prior to establishing governance.

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[146] *Ibid.*

[147] Greene, F. J., and Christian Hopp. "Research: Writing a business plan makes your startup more likely to succeed." Harvard Business Review (2017): 14.

[148] *Ibid.*

[149] Steve Blank. "HBR's 10 Must Reads on Entrepreneurship and Startup (featuring Bonus Article 'Why the lean Startup Changes Everything' by Steve Blank)," *Harvard business review Press,* (2018): 35.

[150] *Ibid, 40.*

[151] Former Global Analytics Platform Director, MS Teams interview with author, 19 January 2022.

When there is a better grasp of the data and the type problems to be solved, this is when developing data strategies, literacy programs, and stewardship come into play." [152] As an organization gains maturity, these strategy documents, governance framework and policies become required to keep progressing.[153] An expectation of perfection in the strategy prior to committing the required resources may simply impede the ability to deliver.

Accelerating Organizational Change.

A key lesson learned from GradA is that digital transformation is more challenging from a change management aspect than a technical one. Although the technical complexity of modernizing and integrating emerging technology cannot be minimized, many of the obstacles to gaining momentum were the ingrained habits and resistance from the staff and users. Changing legacy processes is harder than it should be. Although CANSOFCOM is arguably the most innovative organization within the CAF, Roger's diffusion of innovations could still be observed.

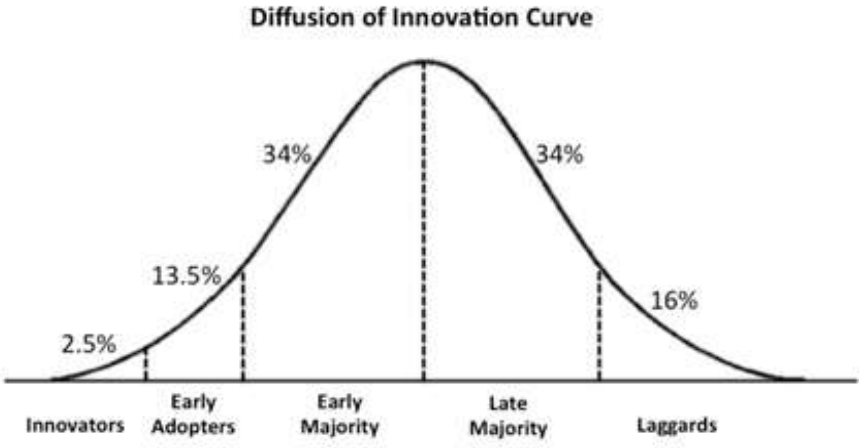

Figure 2.1 – Everett Roger's diffusion of innovation. [154]

[152] *Ibid.*
[153] *Ibid.*
[154] Britannica Academic, s.v. "Diffusion of innovations," accessed May 2, 2022, https://academic-eb-com.cfc.idm.oclc.org/levels/collegiate/article/diffusion-of-innovations/627655.

Within CANSOFCOM's headquarters, the staff had a stronger reluctance to use custom-built digitalized workflows and analytics dashboards to manipulate their data. Under time pressure, they often reverted to using Microsoft Office tools (Excel and PowerPoint) and manual data consolidation via email instead of more efficient digital workflows. Inefficient methods gave a sense of comfort leading to maintenance of the status quo. Nevertheless, the tipping point of adoption happened when the deputy commander mandated to be briefed through modern digital tools and analytics dashboards, forcing units and staff to populate their data in custom-built applications using the new data architecture. Moreover, a highly influential Chief Warrant Officer took on the responsibility to drive that change within the operations cells across the Command. This CWO used his credibility and influence to incite change and rally other peers in this movement. The combo of leadership endorsement and peer enforcement accelerated the transition for both the early and late majority, thereby, enabling the transition from legacy time-consuming data collection methods to data-centric workflows. Yet, success is not tied to single events but to an accumulation of key actions and milestones associated with successful change management.

Challenges with organizational change have been studied for decades. One of the most influential models is the *Kotter's 8-step process for Leading Change*[155], built in the 90s. Kotter's models describe the likelihood to achieve success as follows:

1. Create a sense of urgency.
2. Build a guiding coalition.

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[155] John Kotter, "The 8-Step Process for Leading Change", last accessed 02 May 2022, https://www.kotterinc.com/8-step-process-for-leading-change/

3. Form a strategic vision and initiatives.
4. Enlist a volunteer army.
5. Enable action by removing barriers.
6. Generate short-term wins.
7. Sustain acceleration.
8. Institute change.

However, it is argued that Kotter's model doesn't consider the speed and sequencing in which the change must take place. Kotter's model provides key conditions of "what" is required for that change but does not provide the "how" to implement it.[156]

The book Fast Forward[157], written by Elspeth J. Murray and Peter R. Richardson, is a practical model on the "why" and "how" of implementing organizational change in both the private and public sectors.

Murray and Richardson propose that the key difference between success and failure is tied to the ability to establish the winning conditions within the first 100 to 200 days of a change initiative. They assess that "the first 100 days is winning the hearts and minds of the initial 20% of employees who will actively support the new plan"[158] for change. But moreover, this first period will solidify stakeholder support, demonstrate tangible actions that align with short-term objectives, and address the impediments that could torpedo momentum. Such impediments can be related to funding, contracts, or active resistance to

[156] Elspeth J. Murray, and Peter R. Richardson. *Fast forward . . . ,* 8.

[157] This book was written based on more than 20 years of expertise consulting for various businesses across the whole spectrum of industries. Moreover, they conducted studies with more than 30 C-Suite executives of companies across the continents to document their understanding of what leads to success or failure. Leveraging recognized and peer-reviewed literature, they were able to interconnect some of the key change management models into a coherent and reproducible model.

[158] Elspeth J. Murray, and Peter R. Richardson. *Fast forward . . . , 33.*

the change.[159] The second 100 days is about delivering on the first outcomes, gaining more commitments from the early adopters, and realigning resources and priorities to support the initiative.[160] But again, it is all about demonstrating the early benefits of the change.

However, time is not the only factor dictating success as there are a series of winning conditions that must be implemented early. These conditions can be separated into three categories: (1) shared understanding, (2) generating speed, and (3) gaining critical mass.[161]

Shared understanding

1. Correct diagnosis of the change challenge.
2. Early development of shared understanding.
3. Enrichment of shared understanding.

Speed

4. Establishment of a sense of urgency.
5. Creation of a limited and focused strategic agenda.
6. Rapid, strategic decision-making and deployment.

Critical mass

7. A human flywheel of commitment.
8. Identification and management of sources of resistance.
9. Follow-through on changing organization enablers
10. Demonstrate leadership commitment.

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[159] *Ibid,* 100.
[160] *Ibid,* 100.
[161] *Ibid,* 10.

Shared understanding

Murray characterized shared understanding as the alignment of tangible actions to implement a vision into a successful outcome. It is the ability to fundamentally (1) understand the problem to solve, (2) share across the organization the vision of why it's needed, and (3) ensure that the objectives and actions still align with that vision throughout the change process. Shared understanding is highly challenging for organizations as the speed of progress and the understanding of the objectives will divert across business lines or directorates.[162] Varying authorities, processes, and risk tolerance from a directorate to another can stall the progress and kill momentum. In military terms, it is the understanding of the intent, end-state, and situational awareness of the change efforts.

The implementation of shared understanding is done through - a highly controversial topic within business academia - the business model (i.e., campaign plan for military practitioners). Some argue that lengthy business models are inadequate for start-ups and disruptive initiatives as they impede speed and agility.[163] However, a plan enables alignment of internal marketing efforts, ensures alignment and support of other departments, and formalizes the need for funding and resources.

When building a digital factory, there are many dependencies to institutional silos. Thus, significant effort is to be dedicated to key leadership engagement (KLE) and publicizing the strategic plan to remove potential strategic impediments. During the early days of the GAP, the main effort for the director was to build and conduct a KLE strategy with the rank of Col and above to educate the executive leadership on the available

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[162] *Ibid,* 25-26

[163] Blank, Steve. "HBR's 10 Must Reads on Entrepreneurship and Startup (featuring Bonus Article 'Why the lean Startup Changes Everything' by Steve Blank)," *Harvard business review Press,* (2018): 35.

capabilities and their value to support operations overseas. These KLEs allowed them to build confidence and to secure additional support and resources.[164]

Speed

A recurring theme across successful digital factories is that "we just have to get started." A digital factory that can demonstrate value quickly will gain enough momentum and credibility to gain more resources and funding. Murray argues that speed is not exclusive to small organizations. Large and mature organizations (such as the government and the military) can also achieve success if "they can develop processes that specifically enable them to make decisions, commit resources and achieve results quickly."[165] Speed is promoted in literature through various forms in models such as the Lean Startup, Agile, and DevSecOps. Even in military doctrine, speed of action is a key tenet of the manoeuvre approach. Murray's proposal to achieve speed is to (1) establish a sense of urgency, (2) create a limited and focused strategic agenda, and (3) rapid strategic decision-making and deployment.

GradA's sense of urgency was instilled by the deputy commander's expectation to digitalize processes and use data analytics to support decision-making across the Command. Early in the program, he published a two-page Direction and Guidance (D&G) document that gave the vision, the aspirations, and examples of "current ways of doing things" that were no longer seen as good enough. He established a quarterly executive steering committee to validate and enforce prioritization of efforts across digital transformation initiatives. These recurrent validations were conducive to rapid

[164] Former Global Analytics Platform Director, MS Teams interview with author, 19 Jan 2022.
[165] Elspeth J. Murray, and Peter R. Richardson. *Fast forward: Organizational change . . . ,* 18.

readjustment of resourcing and funding, and ensured the acceleration and sustainment of momentum.

From a strategic CAF perspective, speed is tied to the ability to receive executive endorsement and guidance, delegation of authorities, assignment of resources and funding, and supporting the prioritization of procurement and other processes. It is important to note that speed in the context of digital transformation can be categorized between strategic commitment and speed of technical implementation. The latter is implemented through the use of Agile development principles and DevSecOps processes. These will be further explored in Chapter 3.

Critical Mass

Murray's and Kotter's model both outline the need to establish a critical mass of internal employees to drive the change. Murray's "human flywheel of commitment" or Kotter's "coalition of the willing" both emphasize the importance of gathering a group of highly motivated and committed individuals to drive the change. The human flywheel refers to the group of employees that will either embrace the change (20%), stay neutral (70%), or sabotage the efforts (10%).[166] Kotter's coalition of the willing mostly focuses on the identification of champions and volunteers "to guide it, coordinate it and communicate its activities."[167] Others prefer the diffusion of innovation distribution concept to identify innovators, early and late adopters, and laggards. But independently of the model, the selection of the right individuals to kickstart and lead this change will be directly tied to its

[166] *Ibid,* 50.

[167] John Kotter, "The 8-Step Process for Leading Change", last accessed 02 May 2022, https://www.kotterinc.com/8-step-process-for-leading-change/

success. Chapter 4 discusses in more detail, the selection of the digital factory team members.

Murray also argues that the neutral group, also named the "fence sitters," can be vulnerable to the influence of both the "true believers" and the "saboteurs". Based on the theory of the human flywheel, the aim is to identify a high ratio of individuals driving change in comparison to the size of the organization (i.e., change agent / number of employees). However, it is especially difficult for big organizations to drive that change since the size of the group outweighs the size of the change agents. A tipping point is achieved when the ratio of change agents surpasses the number of saboteurs.[168] It is even more difficult for large organizations when they face high employee attrition or downsizing as managers will limit their commitment (time and resources) to the change. They may even decide to outsource the change initiative to consulting companies.[169]

This may sound familiar with the current CAF situation where services are understaffed and military trades suffer from significant attrition.[170] Digital strategies and roadmaps are outsourced to consulting companies which conduct lengthy digital maturity assessments and problem scoping. This approach contradicts one of the key principles for success, speed. Moreover, there is inherent risk that managers re-prioritize resources outside of the change initiative to handle short-term issues to the detriment of long-term objectives.

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[168] Elspeth J. Murray, and Peter R. Richardson. *Fast forward: Organizational change . . . ,* 50.
[169] *Ibid,* 50.
[170] The Canadian Press, "Military dealing with more than 10,000 unfilled positions amid growing pressures," *Toronto Star, 18 January 2022,* https://www.thestar.com/politics/2022/01/18/military-dealing-with-more-than-10000-unfilled-positions-amid-growing-pressures.html

Furthermore, the lack of institutional leadership convergence is one of the primary obstacles that can derail the department's ability to push its digital transformation objectives.[171] To achieve unity, "There is a need for absolute endorsement of the top leadership to force change as a mandatory passage."[172] Currently, "The ultimate authority, to decide, on the duality between IM and digital transformation, does not converge at the DM and CDS level."[173] The responsibility to meet the digital intent, vision, and implementation is left to interpretation across the various Level 1 (L1) organizations (ADMs, environments, etc), which may all have different visions and perceptions of what digital transformation means. Since each L1 has different mandates, objectives, and authorities, institutional coherence is nearly impossible. Especially since digital transformation leads to highly uncomfortable changes in authorities, responsibilities, and accountability (ARA), it requires direct involvement from the top leadership to address divergences.[174] Thus, establishing a CAF digital factory will face challenges at the institutional level, unless the prioritization of its creation is deliberately added as part of a CAF digital strategy.

Hierarchical structure.

The current approach attempted by DND/CAF is to conduct a decentralized execution of digital transformation through a semi-flat structure, but without adapting the hierarchical structure's responsibilities and authorities.

Implementation of Agile methodologies and flat organizations to stimulate creativity and innovative thinking is a recurrent topic. Unfortunately, the organization is

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[171] Christiana Cavazonni, (speech, Vanguard C4ISR and Beyond, Ottawa, Canada, 27 Jan 2022.
[172] Christiana Cavazzoni, Former DND executive, MS Teams interview with author, 10 Feb 2022.
[173] *Ibid.*
[174] *Ibid.*

not predisposed to such agility. It is highly hierarchical due to its size and level of maturity, but this is not uncommon. John P. Kotter proposes that successful organizations all go through the same life cycle. They start their journey as a start-up in a network-like organization structure centred on the founder and progress into a more hierarchical organization separated into business lines. This evolution can be explained by the need for efficiency, reliability, and accountability as the organization grows.[175] Therefore, "Innovation leads to growth, but growth hinders innovation".[176] A consequence is the progressive loss of risk-taking and opportunistic culture, valorizing predictability and structure instead. Hierarchical organizations have inherent limitations that are counterproductive to fostering innovation and change. Some limitations are communications silos, policy and bureaucratic processes slowing down execution speed, and an incoherence between long-term vision and short-term decisions and actions.[177] Moreover, the social and political environment within hierarchical organizations becomes a systemic issue of change resistance and of insufficient buy-in.[178] However, organizations can still foster innovation by creating flatter organizations by creating a Dual Operating System.

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[175] John P. Kotter, *Accelerate: Building Strategic Agility for a Faster-Moving World*. Harvard Business Review Press, 2014, 4-6.

[176] Chamorro-Premuzic, T., "The five characteristics of successful innovators". Harvard Business Review, (2013): 4.

[177] John P. Kotter, *Accelerate: Building Strategic . . .,* 8.

[178] *Ibid.*

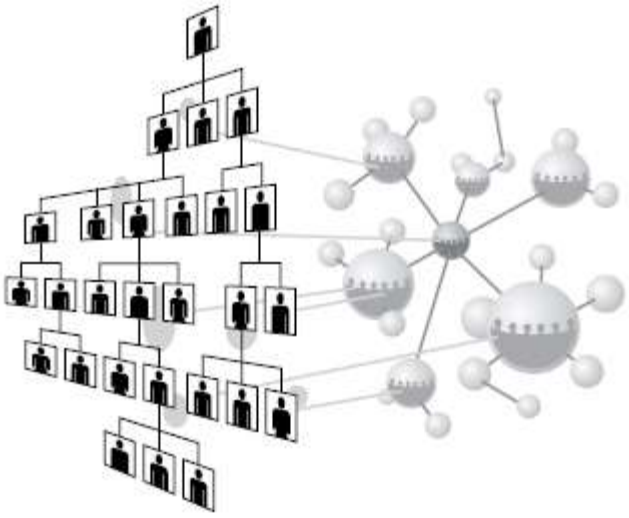

Figure 2.2 – Kotter's Dual System approach.

It is important to realize that the CAF/DND structure was initially built through an analog approach, where all digital functions are siloed. For example, Data/IT architecture and infrastructure authorities are all centralized within the CIO office. The CIO's main responsibility is to provide stability, security, and standardization of systems. These responsibilities contrast with the short-term "chaos" created by the prototyping and experimentation that are required to innovate.

Therefore, the organization is built to be rigid by design. A perfect example of this rigidity was with the establishment of ADM(DIA). Upon creation, their mission was to provide "the expertise required to make data-driven and evidence-based decisions by providing data integration and analytics support, in addition to serving as an innovation support hub."[179] Unfortunately, a lack of authorities led them towards an unavoidable path

[179] Department of National Defence, "Organizational Structure: ADM(DIA)", https://www.canada.ca/en/department-national-defence/corporate/organizational-structure/assistant-deputy-minister-data-innovation-analytics.html

of becoming a policy centre.[180] This transition happened since they had no authority to dictate architectural changes and implement the tooling and the technology required to execute their vision.

Without rapid and timely policy change, it becomes difficult to strategically align an organization as new initiatives can't get the proper support to execute on their digital transformation objectives.[181] The L1s are then forced to implement digital transformation through a legacy authority structure, favouring waterfall project management instead of modern Agile development methodologies, and squashing their ability to implement true innovation.

A Dual Operating System provides flexibility in establishing both a hierarchical and a network-like structure that work in parallel. It enables them to address the various challenges facing the organization when agility is required without compromising the overall business structure. While the hierarchical structure focuses on the daily running of the enterprise, the network-like organization can tackle initiatives that require innovative and creative thinking, speed, and significant change management.[182] Hence, many organizations in the private sector implement digital factories to break organizational inertia and accelerate their digital transformation. By building a Dual Operating System, it creates ecosystems where expertise across the various silos converges around the same purpose. The organization then inherits the essential relationship to remove bureaucratic impediments to its success. Various departments can contribute resources to the digital

[180] Christiana Cavazzoni, Former DND executive, MS Teams interview with author, 10 Feb 2022.
[181] *Ibid*.
[182]John P. Kotter, *Accelerate: Building Strategic . .21.*

factory and enable a wider reach and influence across each functional silo's authorities. The structure of the digital factory is proposed in Chapter 4.

CHAPTER 3: CULTURE AND PROCESSES

"If you are not embarrassed by the first version of your product, you've launched too late."

— Reid Garret Hoffman

Software development has evolved over the years, through multiple movements, frameworks, and methodologies. The need for business agility and responding to a highly competitive market mandated faster development cycles and accelerated delivery of new products into the market. The legacy waterfall methodology to delivering software projects is considered too rigid to adapt to customer requirement changes, lacks input from the customers, and increase the chance of long-term delays.[183] Prior to the 2000s, delivering new software could take years, and the risk of a misalignment between the market need and the product could jeopardize the business.[184]

Waterfall is still present across government project management. In fact, many digital factories in the US stem from the fusion of failed software projects.[185] KR and the GAP both emerged from the fusion of multiple software project teams that, at the time, had varying levels of success. Both digital factories were built leveraging the personnel, resources, and funding from across the project team, and realigned towards an Agile product management and DevSecOps approach to deliver better value to their parent organizations.[186] These two movements are adopted across digital factories both in the

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[183] Jason Fair, "Agile versus Waterfall: Which aproach is right for my ERP project?", Presented at PMI Global Congress 2012, (Marsailles: Project Management Institute, 2012.) https://www.pmi.org/learning/library/agile-versus-waterfall-approach-erp-project-6300

[184] Kim, Gene, Jez Humble, Patrick Debois, John Willis, and Nicole Forsgren. The DevOps handbook: How to create world-class agility, reliability, & security in technology organizations. IT Revolution, 2021, XXIII.

[185] Jenny Aroune, Robert Hollister, and Nathan Taylor. "Kessel Run: An Analysis . . . , 41.

[186] Former Global Analytics Platform Director, MS Teams interview with author, 19 January 2022.

private and public sector. Many big-tech companies even developed their own flavour of Agile and DevSecOps, such as Site Reliability Engineering (SRE)[187] from Google and the Guild Model[188] from Spotify. Although mutually supportive, both models have their differences and are applied for different purposes. This chapter will explore how Agile and DevSecOps support digital factories.

Agile

Agile is a product management and development philosophy. It "relies on fast-moving, self-managing teams for innovation."[189] Although not exclusive to software development, it is defined by Atlassian as "an iterative approach to project management and software development that helps teams deliver value to their customers faster".[190] The agile philosophy stems from *The Agile Manifesto* which was developed by a group of software development professionals at a conference in 2001.[191] The manifesto identifies four values and twelve principles of software development.[192] Over time, multiple methodologies and concepts were developed from these principles. Agile can be implemented across the enterprise by modifying processes and policies in support of iterative project management. It is also implemented at the development team level with the concept of Agile product delivery. Agile product delivery leverages customer centricity

[187] Google, "What is Site Reliability Engineering (SRE)?," last accessed 02 May 2022, https://sre.google/

[188] Mark Cruth, "Discover the Spotify model", *Atlassian Agile Coach,* last accessed 02 May 2022, https://www.atlassian.com/agile/agile-at-scale/spotify

[189] Darrell Rigby, Sarah Elk, and Steve Berez. *Doing Agile Right: Transformation without Chaos*. La Vergne: Harvard Business Review Press, 2020, 1. https://go.exlibris.link/tw8Xxh65.

[190] Atlassian, "The Agile Coach: Atlassian's no-nonsence guide to agile development", last accessed 02 May 2022, https://www.atlassian.com/agile

[191] Claire Drumond, "Is the Agile Manifesto still a thing?" *Atlassian The Agile Coach,* last accessed 02 May 2022, https://www.atlassian.com/agile/manifesto

[192] *Ibid.*

and design thinking to develop a Minimum Viable Product (MVP) as quickly as possible.[193] The MVP is a product that provides enough features to enable maximum learning from customer feedback with the least amount of development effort.[194] [195] Figure 3.1 is one of the most iconic visual representations of the lean and agile development movement.[196] Iterative development is about building a usable prototype. From the first release, it should meet the customer's needs. It may not have all the required features implemented but should have enough for the customer to get value and to provide feedback.

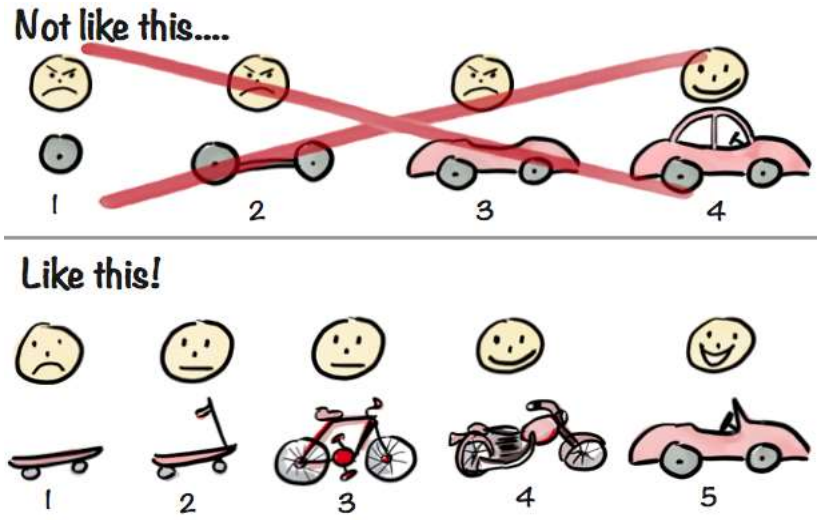

Figure 3.1 – Henrik Kniberg's representation of the MVP design through agile iteration.

A challenge with Agile product development is the threshold of when a product is considered "done". The end-state of a product is difficult to articulate as it can only be

[193] Scaled Agile Framework for Enterprise, "Agile Product Delivery", last updated 27 September 2021. https://www.scaledagileframework.com/agile-product-delivery/

[194] Eric Ries. The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. New York: Crown Business, 93.

[195] Eric Reis, "Minimum Viable Product", *Startup Lessons Learned* (blog), last modified 3 August 2009, http://www.startuplessonslearned.com/2009/08/minimum-viable-product-guide.html

[196] Henrik Kniberg, "Making Sense of MVP (Minimum Viable Product) – and why I prefer Earliest Testable/Usable/Lovable." *Crisp* (blog). https://blog.crisp.se/2016/01/25/henrikkniberg/making-sense-of-mvp

defined after a few iterations at least. At the executive level, this can be very disconcerting to understand and accept. Therefore, executive leadership must have faith in the process, and have a stronger tolerance to risk in the short-term.

Agile provides many benefits. It accelerates the software development life cycle, improves predictability, provides a closer customer-to-development relationship, increases flexibility in accepting changes, and reduces the overall financial impact of pivoting.[197] From a human perspective, a second-order effect is improved productivity and employee satisfaction.[198] At the strategic level, it lowers project risks, and improves business value to the customer.[199]

A main difficulty in adopting Agile methodologies within large organizations is the perception that it can simply be mandated through the implementation of a framework all at once. The successful approach is not to scale agile, but to grow into agile. This means that a big, hierarchical organization needs to first adopt an agile culture and gain experience developing with agile principles as "large-scale transformations are fraught with challenges, such as communication issues, a lack of flexibility, and coordination challenges".[200]

To better understand agile, leadership must understand three main concepts which are the scrum methodology, agile teams, and the scaling process.

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[197] Jose Maria Delos Santos, "Agile vs. Waterfall : Differences in Software Development Methodologies", last modified 14 April 2022. https://project-management.com/agile-vs-waterfall/#differences

[198] Darrell Rigby, Sarah Elk, and Steve Berez. *Doing Agile Right . . .,. 43.*

[199] *Ibid, 43.*

[200] Kieran Conboy, and Noel Carroll. "Implementing Large-Scale Agile Frameworks: Challenges and Recommendations." IEEE Software 36, no. 2 (2019), 44.

Agile Scrum Framework

Scrum is an agile methodology that is widely adopted at the software development team level and across various Agile-at-scale frameworks. Scrum is the "battle rhythm" of the agile team. Within the scrum framework, development is structured in sprints which vary between 1 and 4 weeks in length. Sprint lengths are defined by the team and vary based on effectiveness and experience. An inexperienced team may have 4-week sprints, whereas a highly experienced team may prefer 1-week sprints. Each sprint's objectives are defined by the Product Owner and identified as part of a backlog. The backlog are features that are defined between the Product Owner and the customer (or Business Owner). It is reprioritized iteratively before every sprint. At the beginning of each sprint, the agile team identifies the features to be implemented and the task breakdown for each. Throughout the sprint, the agile team conducts daily stand-up meetings which are led by a scrum master. These meetings are short and have a function to identify which tasks are to be completed by each team member. It also serves as a venue to identify any roadblock that could impede the team's velocity and put the objectives of that sprint at risk.

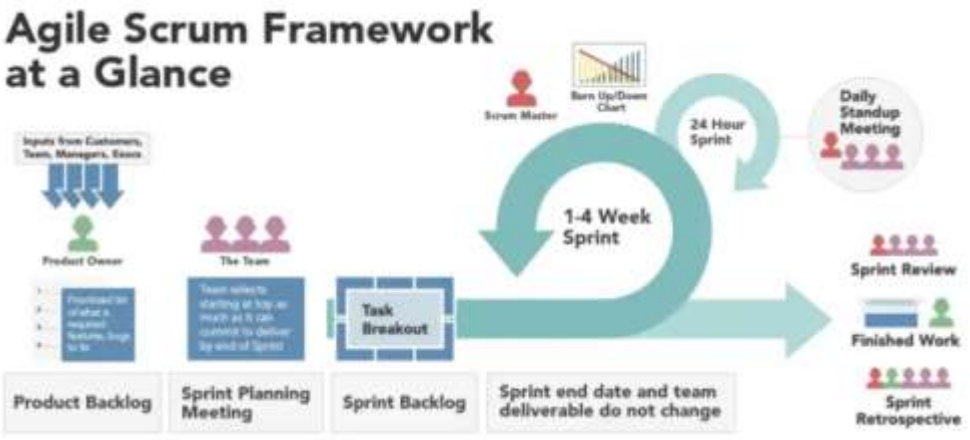

Figure 3.2 – Visualisation of the sprint within the Agile Scrum Framework.[201]

After each sprint, the team conducts a demo to the customer and the stakeholders and demonstrates the features that were built during that sprint. If the demo is endorsed, development continues in subsequent sprints. If it is unsuitable, then it can either be reworked or dropped from the backlog. The benefit of such a short sprint is that if the development team is on the wrong path, it only wasted a few weeks of development instead of months.

A key principle of scrum is that a sprint cannot be interrupted with spontaneous requirements. A fixed sprint provides predictability for leadership on the output and the work effort. Also, it removes chaos from the developer's weekly workload. Developers require uninterrupted time to be productive. Moreover, leveraging the sprint formats allows, over time, to identify the team's velocity. Velocity is a metric to better predict realistic output, as well as to identify changes in productivity.

Another principle is that an agile team must minimize Work in Progress (WIP). WIP are tasks that are not being worked on although they are identified as part of an active pipeline.[202] As identified in figure 3.2, WIP loses value over time as requirements may change, or the need for such tasks may disappear. Therefore, sprints favour work done in smaller batches with faster delivery.[203]

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[201] Planview, "Introduction: A Look at Agile", *Agile Methodologies: A Beginner's Guide* (blog), last accessed 03 May 2022. https://www.planview.com/resources/guide/agile-methodologies-a-beginners-guide/basics-benefits-agile-method/

[202] Darrell Rigby, Sarah Elk, and Steve Berez. *Doing Agile Right . . .,. 41.*

[203] *Ibid, 41*.

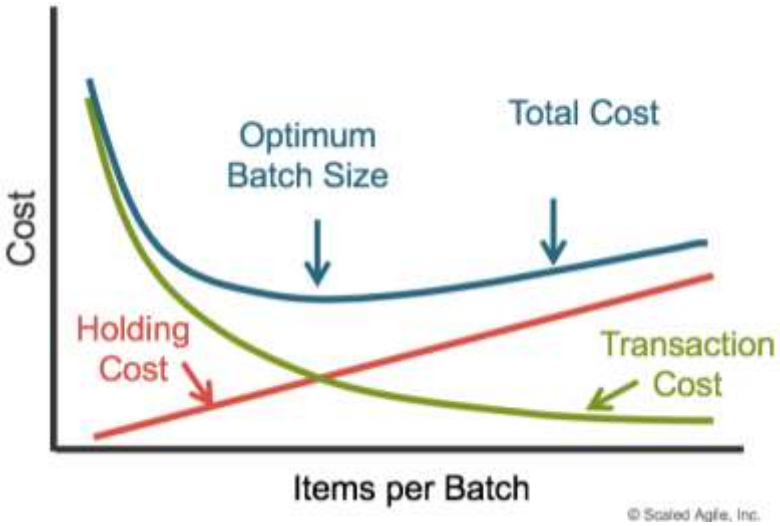

Figure 3.2 – U-Curve optimization for batch size.[204]

Agile Teams

The Agile team is a small cross-functional team between 5 and 11 members[205] that design, build, and test software in small increments.[206] The benefit of these cross-functioning teams allows the removal of the standard functional silos (i.e., requirements, engineering, IT, software development, etc.) that would normally be seen in traditional project management processes and hierarchical organizations. A fundamental prerequisite for success is an acceptance that innovation must be decentralized and must happen at the edge, closer to the customer.[207] Innovation will be driven by the types of problems that are required to be solved and it must be driven from the feedback of customers instead of management's intuition.[208]

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[204] Scaled Agile Framework for Enterprise, "Principle #6 – Visualize and limit WIP", last updated 27 September 2021. https://www.scaledagileframework.com/visualize-and-limit-wip-reduce-batch-sizes-and-manage-queue-lengths/

[205] These numbers vary based on the SAFE framework. However, there is no agreement in literature and team size vary between 3 to 12 members.

[206] Scaled Agile Framework for Enterprise, "The Agile Team", last updated 27 September 2021. https://scaledagileframework.com/agile-teams/

[207] Darrell Rigby, Sarah Elk, and Steve Berez. *Doing Agile Right . . .,. 40.*

[208] Darrell Rigby, Sarah Elk, and Steve Berez. *Doing Agile Right . . .,. 43.*

There is no rigid template on the type of expertise and skills that should be part of an agile team. As an example, an agile team working on data-heavy problems and leveraging AI will include a heavier footprint of data professionals (i.e., data scientists, data engineers, and AI engineers) compared to a team that focuses more on the development of web applications. Nevertheless, the team construct should align with the type of products they support, and it should change as little as possible to ensure continuity and cohesion.

These teams are self-organizing, self-managing, highly independent, high performing, and bridge the needs of customers to technologies.[209] Moreover, there is less formal structural hierarchy. Each member of the team has defined roles, they lead in their respective area of expertise, and contribute to the overall team effort.

There are two key roles within the agile team which is the product owner and the scrum master. The *product owner* is the person who interfaces between the customer and the development teams. They ensure that the requirements (stories) and features of a product are captured, planned on a roadmap, and are prioritized for implementation. They are also responsible to oversee the overall lifecycle and risk management of a specific product. However, the product owner does not manage the technical work. That is the role of the scrum master.

The *scrum master* is often a senior developer with a strong technical background (although not necessarily a mandatory requirement). They coordinate and facilitate the execution of technical tasks internal to the team based on the priorities given by the product owner. Scrum masters also de-conflict tasks with other agile teams' scrum masters.

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[209] *Ibid, 43.*

Scaling Agile

Agile is widely adopted by small development teams within the software industry, especially because of the lower risk to project development.[210] It is estimated that more than "85% of software development teams use agile techniques in their work."[211] Nevertheless, Agile doesn't scale easily beyond the small team; hence various frameworks were developed to synchronize effort beyond the single agile team. Scaled Agile Framework for enterprise (SAFe) and Scrum of Scrums (SoS) are two of the main Agile-at-scale frameworks.[212] A survey on the implementation of Agile across large organizations identified that 29% implemented SAFe and 28% implemented SoS.[213] As there is no "cookie cutter" methodology that suits all businesses, many organizations (14%)[214] implement a custom version using multiple frameworks. Thus, one digital factory to the next will have different methodologies.

Across the various frameworks, the organizational construct remains similar. At the lowest level, there is a *product* that is implemented by an agile team. A level above is a *program*. A program is composed of multiple products. Normally, a program will be aligned with a specific line of effort or capability that supports a specific objective. For example, a line of effort (program) that focuses on operational problems can have multiple products such as a Common Operating Picture (COP) tool, a Situation Report (SITREP) tracker, an automated voice-to-text tool for radio logs, and other types of products that fit within the operational function. Above the program is the portfolio. A portfolio is

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[210] Christof Ebert and Maria Paasivaara. "Scaling Agile" IEEE Software, Vol. 34 (2017), 98.

[211] Darrell Rigby, Sarah Elk, and Steve Berez. *Doing Agile Right . . .,* 1.

[212] Kalenda, Martin, Petr Hyna, and Bruno Rossi. "Scaling Agile in Large Organizations: Practices, Challenges, and Success Factors." *Journal of Software: Evolution and Process* 30, no. 10 (2018): 3.

[213] *Ibid*, 3.

[214] *Ibid*, 3.

composed of multiple programs (and/or program-of-programs) and is mainly focused on aligning strategic level vision to operational execution.[215] Leaders at the portfolio level will focus on developing a vision and a strategy, assessing outputs, managing funding and investments, developing longer term development objectives (Epics), and enabling the establishment of lean processes across the enterprise. Scaling agile often struggles at the portfolio level as it starts competing with the rigid hierarchical and siloed processes of the overall business. Thus, many of the digital factories implement a hybrid format of a hierarchical structure composed of multiple agile programs.

Scaling Challenges

Scaling agile is not simple. A common mistake is that organizations initiate their transformation through the ad hoc selection of a framework.[216] There is a perception that scaling agile is simply a question of applying a framework, and assigning more resources, funding, and authorities. As proposed by the AFC CDO, "Simply scaling requirements and resources is scaling to fail".[217] He argues that without the proper culture, training, and education, an organization will lack the level of coherence and effectiveness that is required to achieve success.[218] An organization does not simply implement agile but grows into agile with the proper coaching and leadership endorsement. Moreover, the choice of a framework must be done based on an organization's own measure of success and based on "best fit and value".[219]

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[215] Scaled Agile Framework for Enterprise, "Portfolio SAFe", last updated 27 September 2021. https://www.scaledagileframework.com/portfolio-safe/

[216] Kieran Conboy, and Noel Carroll. "Implementing Large-Scale Agile Frameworks: Challenges and Recommendations." IEEE Software 36, no. 2 (2019): 46

[217] Army Future Command Chief Data Officer, MS Teams interview with author, 21 Feb 2022.

[218] *Ibid.*

[219] Christof Ebert and Maria Paasivaara. "Scaling Agile" IEEE Software, Vol. 34 (2017): 100.

In many cases, the lack of coaching resources and leadership endorsement forces some managers to take on the role of agile champion, although their experience and expertise in scaling agile are lacking.[220] Unfortunately, poor implementation leads to employee dissatisfaction at the technical level.[221] Inexperienced champions can overemphasize the implementation of a scaling framework instead of the value it should provide.[222] It can lead to inconsistencies at the team level, generating frustration and change fatigue.[223] It was demonstrated that teams with dedicated mentors performed better.[224] Also, it was demonstrated that poor and confused implementations can lead development teams into taking a passive approach or impeding the change process of adopting agile.[225]

Agile is disruptive to people since the team members' roles and responsibilities can change significantly. As agile teams are self-managing and "flatter", some middle managers often don't understand their new role as part of the team.[226] Some struggle to find their purpose in enabling the agile teams and tend to micromanage the agile process and tasks.[227] At the development team level, agile brings process and structure. Senior developers with broad responsibilities and authorities can perceive these changes as more restrictive and rigid. "Today's developers expect and often demand autonomy in how they work" and "it is already known that autonomy becomes increasingly difficult at scale."[228]

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[220] Kalenda, Martin, Petr Hyna, and Bruno Rossi. "Scaling Agile in Large Organizations . . . , 9.
[221] Darrell Rigby, Sarah Elk, and Steve Berez. *Doing Agile Right . . .,* 1.
[222] Kieran Conboy, and Noel Carroll. "Implementing Large-Scale Agile Frameworks: Challenges and Recommendations." IEEE Software 36, no. 2 (2019): 45.
[223] *Ibid, 49 and 51.*
[224] Kalenda, Martin, Petr Hyna, and Bruno Rossi. "Scaling Agile in Large Organizations . . . , 9.
[225] Kieran Conboy, and Noel Carroll. "Implementing Large-Scale . . . , 46.
[226] Kalenda, Martin, Petr Hyna, and Bruno Rossi. "Scaling Agile in Large Organizations . . . , 8.
[227] *Ibid,* 8.
[228] Kieran Conboy, and Noel Carroll. "Implementing Large-Scale . . . , 49.

Thus, a problem arises where leadership must become more flexible and developers must become more structured.

Implementing an agile digital factory requires a deliberate and methodical approach. Like military operations, "Scaling a section to a battalion overnight would be doomed to fail without the proper structure of leadership and knowledge required to conduct operations at the battalion level."[229] The same concepts apply to digital factories. It is about starting small, demonstrating value, and proving the worth of such methodologies to those who are skeptical. Otherwise, skeptics may become an obstacle to the speed and momentum required to achieve success.

DevSecOps and CI/CD

There is an inherent duality between the goals of the development team to "respond to the rapidly changing competitive landscape" and the IT operations to "provide stable, reliable and secure service to the customer."[230] Although agile development has revolutionized the software development process, it did not address the ability to deploy new applications into production (i.e., the IT environment in which the users are able to interact with the application). The need for Dev agility "placed new demands on infrastructure operations teams who were, after decades of ITIL and risk aversion, poorly positioned to adapt to these faster cycles of constant change."[231] Therefore, software organizations trying to become more agile faced unavoidable friction between their development and infrastructure operations teams.

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[229] Army Future Command Chief Data Officer, MS Teams interview with author, 21 Feb 2022.

[230] Gene Kim, and al. The DevOps handbook: How to create world-class agility . . ., XXV

[231] Mandy Storbakken, "DevOps: Where are We and How Did We Get Here?," *VMWare Cloud Management*, last modified 21 May 2020. https://blogs.vmware.com/management/2020/05/devops-where-are-we-and-how-did-we-get-here.html

DevSecOps is a culture, a philosophy, and a framework that bridges the gap between development, security, and IT Ops. It leverages processes, tools, and automation to tightly integrate the agile process of software development and the service delivery process of IT teams. From a culture perspective, the DoD DevSecOps foundational documents include 11 "key principles to successfully transition to a DevSecOps culture":[232]

- Continuous delivery of small incremental changes.
- Bolt-on security is weaker than security baked into the fabric of the software artifact.
- Value open-source software.
- Engage users early and often.
- Prefer user centred & Warfighter focus and design.
- Value automating repeated manual processes to the maximum extent possible.
- Fail fast, learn fast, but don't fail twice for the same reason.
- Fail responsibly; fail forward.
- Treat every API as a first-class citizen.
- Good code always has documentation as close to the code as possible."
- Recognize the strategic value of data; ensure its potential is not unintentionally compromised.

In fact, these principles are proven to be at the foundation of high-performing software organizations. Google's State of DevOps proposes that the "faster the teams can

[232] United States. Department of Defense, DoD Enterprise DevSecOps Fundamentals, (March 2021), 19.

make changes to the software, the sooner you can deliver value to the customers, run experiments, and receive valuable feedback".[233] Their research – data gathered from more than 32,000 professionals – indicate that the highest performers in DevOps keep decreasing their lead time to make changes to production, leverage the cloud extensively to deliver software, focuses on the secure software supply chain, have improved internal documentation, and fosters positive team culture.[234] Based across 5 performance metrics, the elite organizations can deploy code into production multiple times per day; they conduct changes, restore services in less than an hour, and have less than 15% change failure rate.[235] Based on their study, the elite organization is able to deploy code and recover from the incident 6570x times faster than non-DevOps organizations.[236] Figure 3.3 demonstrates Google's software delivery performance categorization.

Aspect of Software Delivery Performance*	Elite	High	Medium	Low
Deployment frequency For the primary application or service you work on, how often does your organization deploy code to production or release it to end users?	On-demand (multiple deploys per day)	Between once per day and once per week	Between once per week and once per month	Between once per month and once every six months
Lead time for changes For the primary application or service you work on, what is your lead time for changes (i.e., how long does it take to go from code committed to code successfully running in production)?	Less than one day	Between one day and one week	Between one week and one month	Between one month and six months
Time to restore service For the primary application or service you work on, how long does it generally take to restore service when a service incident or a defect that impacts users occurs (e.g., unplanned outage or service impairment)?	Less than one hour	Less than one day[a]	Less than one day[a]	Between one week and one month
Change failure rate For the primary application or service you work on, what percentage of changes to production or released to users result in degraded service (e.g., lead to service impairment or service outage) and subsequently require remediation (e.g., require a hotfix, rollback, fix forward, patch)?	0-15%[b,c]	0-15%[b,d]	0-15%[b,d]	46-60%

Figure 3.3 - Aspect of Software Delivery Performance (State of DevOps 2019)

[233] Smith, Dustin, Daniella Villalba, Michele Irvine, Dave Stanke, Nethen Harvey Smith. "2021 Accelerate State of Devops Report." (2021): 9.
[234] *Ibid,* 7.
[235] *Ibid,* 9.
[236] *Ibid,* 13.

On top of culture, DevSecOps is a process for continuous software delivery, in which the software lifecycle is represented by the DevSecOps loop in Figure 3.4. On top of the integration between Dev and Ops, DevSecOps includes the integration of automated security checks (active and passive) to identify potential vulnerabilities of new software within the environment.[237]

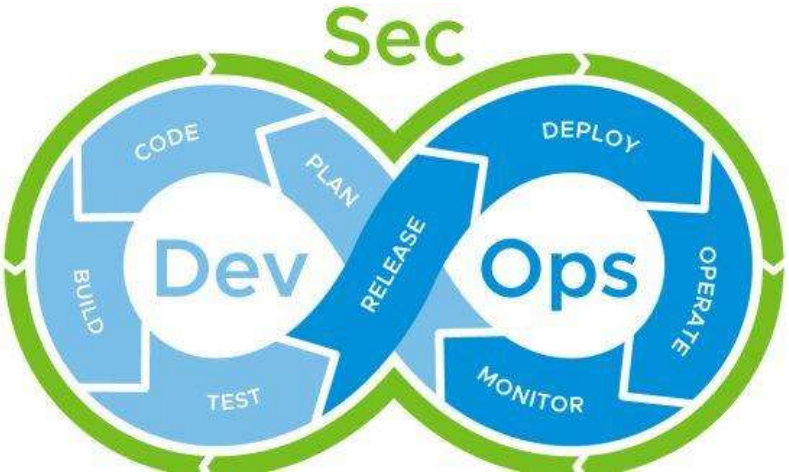

Figure 3.4 – Visual Representation of the DevSecOps loop[238]

Plan-Code-Build-Test is the process of leveraging agile methodologies to design the application (plan), to code and integrate the various features of the application (code), to make the code executable in a form that can be deployed into the environment (build), and to ensure that the code works properly with no bugs remaining (test). [239] This process resides mainly under the purview of the development team.

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[237] Red Hat, "What is DevSecOps?" last modified 12 April 2018. https://www.redhat.com/en/topics/devops/what-is-devsecops#:~:text=DevSecOps%20stands%20for%20development%2C%20security,throughout%20the%20entire%20IT%20lifecycle.

[238] Mandy Storbakken, "DevOps: Where are We and How Did We Get Here?," *VMWare Cloud Management*, last modified 21 May 2020. https://blogs.vmware.com/management/2020/05/devops-where-are-we-and-how-did-we-get-here.html

[239] "DevOps In 5 Minutes | What Is DevOps?| DevOps Explained | DevOps Tutorial For Beginners |Simplilearn" Youtube video, 5:01. Posted by "Simplilearn," 16 Feb 2021. https://www.youtube.com/watch?v=Xrgk023l4lI

Release-Deploy-Operate-Monitor is the process enabled by the IT Ops team to deploy the newly developed code into the production system. It includes the allocation of IT resources to run the software (deploy), but also to ensure that user can access the service (operate). [240] Upon deployment, the Ops team ensures that services deployed within the environment remain operational and can support the consumer workload.

This DevSecOps process is enabled via the integration of tools and software as part of the DevSecOps toolchain. The DevSecOps toolchain "operates as an integrated unit to design, build, test, manage, measure, and operate software systems."[241] It supports the whole lifecycle of the software development and release process through the implementation of a Continuous Integration (CI) and Continuous Delivery Pipeline (CD) pipeline.

Continuous Integration and Continuous Delivery Pipeline

A main challenge in developing code-at-scale is the need for multiple developers to work in parallel; thus, requiring robust versioning control. Versioning ensures that bugs and errors do not get injected into the main code that could break the system.[242]. The main code is referred to as the "trunk" and the parallel work as "branches."[243] The more "branches" you produce, the more work is required to integrate them to the main trunk.

Manual integration of code is laborious and resource intensive. To compensate, developers will produce more code at a time before merging it, exacerbating the potential

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[240] *Ibid.*

[241] Robert Krohn, "Considerations for your DevOps toolchain," *Atlassian Software Development* (blog), last accessed 02 May 2022, https://www.atlassian.com/devops/devops-tools/choose-devops-tools

[242] GitLab, "CI/CD Concepts." *GitLab Docs* (blog), last accessed 03 May 2020. https://docs.gitlab.com/ee/ci/introduction/

[243] Kev Zettler, "Trunk-Based Development" *Atlassian Software Development* (blog), last accessed 02 May 2022. *https*://www.atlassian.com/continuous-delivery/continuous-integration/trunk-based-development

for bugs and errors.[244] In other words, they are conducting bigger batches at a slower frequency which is opposite to the agile principles of frequent releases in small batches. Automating the integration of code and the delivery processes is integral to the success of DevSecOps.

Continuous Integration is the process and the tools to automate the merging, validation, and testing of code. The automation reduces the chance of injecting faults in the software and ensures that "changes pass all tests, guidelines, and code compliance standards" for the application.[245] The benefit of CI is improved software quality and minimized time to validate and release software updates.[246] GitLab is one of the most leveraged platforms to conduct CI. Figure 3.5 demonstrates the flow process of a CI/CD pipeline within the GitLab environment. Upon review and approval of a branch merge, the new updates are pushed into a staging environment and wait to be deployed into production.[247] This step is enabled by the Continuous Delivery/Continuous Deployment (CD) process.

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[244] Kim, Gene, Jez Humble, Patrick Debois, John Willis, and Nicole Forsgren. The DevOps handbook: How to create world-class agility, reliability, & security in technology organizations. IT Revolution, 2021, 144-151.

[245] GitLab, "CI/CD Concepts." *GitLab Docs* (blog), last accessed 03 May 2020. https://docs.gitlab.com/ee/ci/introduction/

[246] Amazon AWS, "What is Continuous Integration", last accessed 03 May 2022. https://aws.amazon.com/devops/continuous-integration/#:~:text=Continuous%20integration%20is%20a%20DevOps,builds%20and%20tests%20are%20run.

[247] SAFe, "Continuous Delivery Pipeline", *SAFe Documentation.* Last updated 27 September 2021. *https*://www.scaledagileframework.com/continuous-delivery-pipeline/

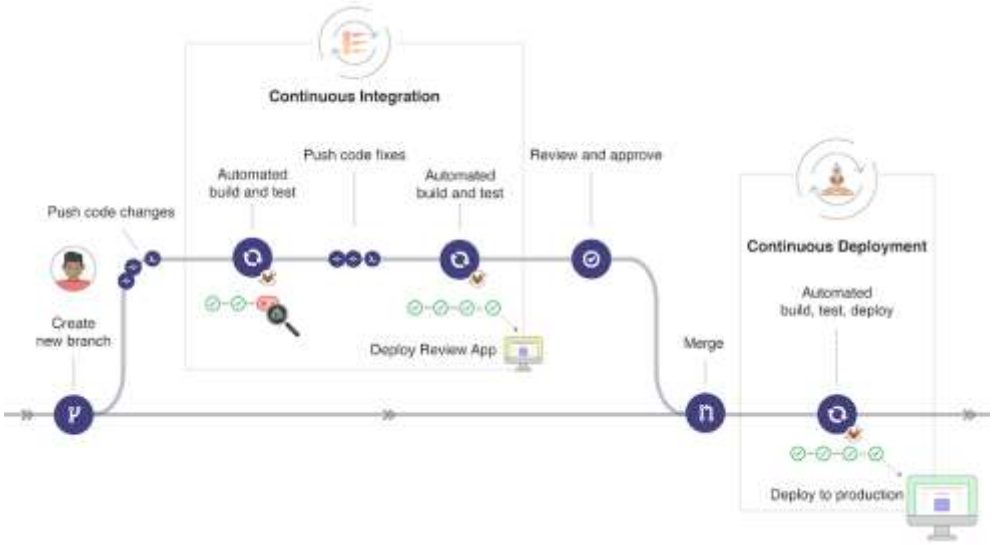

Figure 3.5 – Visualisation of the CI/CD pipeline. [248]

Continuous Delivery is an approach to accelerate the delivery of software in a short and reliable cycle.[249] It enables the "changes of all types—including new features, configuration changes, bug fixes and experiments—into production, or into the hands of users, *safely* and *quickly* in a *sustainable* way."[250] CD's benefits are low-risk releases, faster time-to-market, higher quality, better product, and lower cost enabled by incremental changes.[251]

Within DevSecOps, CD is enabled by the IT Ops team via the use of various software and tools that automate the performance testing, the establishment of the environment, and the orchestration of applications within the environment.[252] CD has also

[248] GitLab, "CI/CD Concepts." *GitLab Docs* (blog), last accessed 03 May 2020. https://docs.gitlab.com/ee/ci/introduction/

[249] Lianping Chen. "Continuous delivery: Huge benefits, but challenges too." IEEE software 32, no. 2 (2015): 50.

[250] Jez Humble. "What is Continuous Delivery?". last accessed 03 May 2020, https://continuousdelivery.com/

[251] *Ibid.*

[252] Ahmad Alnafessah, and al. "Quality-Aware DevOps Research: Where Do We Stand?" *IEEE Access* 9 (2021): 44480.

been accelerated with the emergence of cloud-native applications and the use of containerization.

Finally, the key take-away is that a digital factory's success, like a software business, will depend on the organization's ability to implement Agile and DevSecOps principles. Implementing these principles are in direct contradiction with many legacy IT processes that are in place. To succeed at implementing Agile and DevSecOps, it comes back to many propositions in this paper. First, it requires fundamental knowledge of the framework and the technologies supporting software development. Second, it requires a strategy to implement such an initiative, as it is a significant change management challenge. Third, it requires the adequate expertise to implement such an initiative.

CHAPTER 4: BUILDING THE FORCE

"Great vision without great people is irrelevant."

– Jim Collins, Author of Good to Great

As mentioned in Chapter 2, building a network-like team does not absolve the legitimacy of structure and process, but enables a level of flexibility in roles and responsibilities while enabling speed, momentum, and agility. This chapter will propose a structure and role definition for a digital factory within the CAF. It will leverage the various concepts proposed in the previous chapters, while taking into consideration the interviews and their respective lessons learned. As the sequencing and scaling process for this structure may vary based on the strategy and operating model of the organization, it should act as an initial reference point. The organigram is based on a team structured around leadership, functions, specific problems (i.e., LOE), and specialized teams.

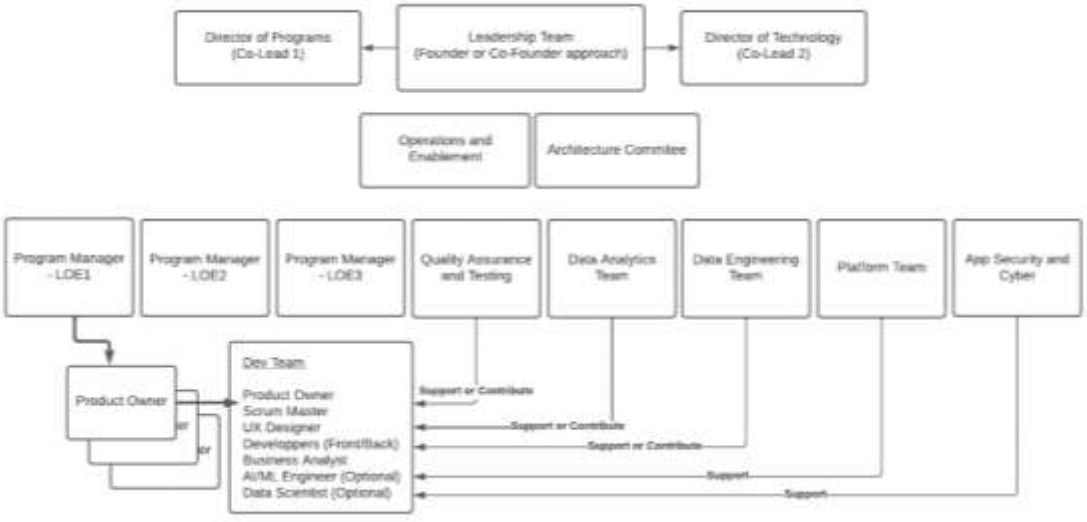

Figure 4.1 – The Digital Factory Organigram.

There are two approaches to establishing the leadership team: one focusing on unity of command and one on shared leadership.

One Lead Approach

Military organizations are more familiar with the approach of a unique leader that "has the authority to direct and control the committed resources and is responsible and accountable for success or failure."[253] This is the approach that was taken by the GAP, in which the director – combat arms by profession with an extensive operational background – applied military doctrine and integrated it with DevSecOps.[254] He also established a leadership structure centred around military professionals of various trades (technical and non-technical) to take the roles of program managers and product owners. The reasoning behind this format was that military members have a stronger understanding of military operations, which provides them an edge in understanding client requirements and getting more value out of the products.[255] To support the leadership, there was also the designation of a chief architect (civilian) to advise on the technical decision-making. However, he also argued during the interview that digital factory leaders from the combat arms cannot exempt themselves from developing in-depth knowledge of technology and software development concepts.[256] Any military members employed in these types of programs should be expected to have completed or to be pursuing continuous education in technological fields such as software engineering, data analytics, cloud computing, Agile, and DevSecOps.[257] Without technical middle managers and executive leaders, there can be

[253] Department of National Defence, B-GJ-005-000FP-001, Canadian Military Doctrine. Ottawa: DND Canada, 2009, 5-3.
[254] Former Global Analytics Platform Director, MS Teams interview with author, 19 Jan 2022.
[255] Former Global Analytics Platform Director, MS Teams interview with author, 19 Jan 2022.
[256] *Ibid.*
[257] *Ibid.*

a significant divide between the end user and the developers.[258] On the other hand, those who have extensive academic background in engineering tend to gravitate more to roles related to software development, analytics, and platform engineering. Thus, the natural evolution of the organization led toward the employment of military personnel with operational backgrounds into program and product management roles, whereas those with technical backgrounds were employed in technical roles. Nevertheless, a common denominator across the military practitioners was the strong baseline of knowledge related to software development and data analytics.

Co-Lead Approach

Finding leaders that can lead a digital factory can be difficult as they must possess strong credibility with the organization's leadership and possess a strong understanding of the business, products, and technological platforms.[259] The alternative is an approach seen extensively in the tech start-up industry, the co-founder or co-lead model. This approach to command and control was adopted by the GradA program. In that use case, the lead of products was an experienced Infantry Officer with extensive background in operations and data-driven decision-making, whereas the lead of technology was a Signals Officer with a background in computer engineering and data analytics. Although this co-lead relationship is unconventional in the military, it was highly effective. First, it enabled the leveraging of the strengths of both leads in their areas of expertise. The lead of the product had credibility with the operational community that provided a level of access to senior leadership and the user community that was essential to the success of the program. On the other hand, the

[258] Army Future Command Chief Data Officer, MS Teams interview with author, 21 Feb 2022.

[259] Rohit Bhapkar, Erez Eizeman, Joao Dias, Irene Floretta, and Marta Rohr. "Scaling a Transformative Culture through a Digital Factory." *McKinsey Insights* (2017), 6.

lead of technology had the technical understanding of the IT systems and an access to the engineering and software community within and outside CANSOFCOM. Nevertheless, it was not without challenges. Having a co-lead approach required constant negotiation and compromises driven by divergent vision at times. Therefore, it challenged the leadership to find the best plans to find alignment. Another benefit of the co-lead approach is to challenge the inherent professional biases that each can bring into the equation. As part of the GradA experience, it ensured that the need for short-term operational requirements did not compromise the long-term technological vision, and that the technical endeavours were focused and addressed the right operational needs.

Technical vs Non-Technical Leadership

A recurring question is whether institutional leaders and managers of such an initiative require technical understanding or be based primarily on their leadership abilities. It was demonstrated that the knowledge base of managers directly correlates with their level of comfort in making decisions based on analytics products and technology. [260] A lack of understanding can generate discomfort and uncertainty in the perceived ability to make the right decision.[261] In fact, coming from a technical background is becoming more prevalent to occupy leadership roles. In 2017 and 2018, the "best-performing CEOs in the world were more likely to have an engineering degree than an MBA".[262] The consulting firm McKenzie and Co. also identified that the top-performing companies significantly

[260] Ransbotham, Sam, David Kiron, and Pamela Kirk Prentice. "Minding the analytics gap." *MIT sloan management review* 56, no. 3 (2015): 64.

[261] *Ibid,* 66.

[262] Jena McGregor, "More top-performing CEOs now have engineering degrees than MBAs", last updated 22 October 2018. https://www.washingtonpost.com/business/2018/10/22/more-top-performing-ceos-now-have-engineering-degrees-than-mbas/?fbclid=IwAR27oQW2wBYIF4zdIchrkHfliJy-nmf_uh8uDXe9XM_Hxp7t72G7F32XCwI

involve their senior technology leaders in enterprise-wide strategy and business agenda.[263] Thus, there is a shift in paradigm. The institutional leaders of tomorrow requires technical background and cannot rely solely on their strong leadership abilities and operational experiences. It isn't only tied to technical decision making, but to overall risk management abilities.

Former USAF CSO Nicolas Chaillan, in his resignation letter, highlighted the poor approach taken by the military in assigning generalists to highly complex digital transformation initiatives, especially at the mid-rank manager level.[264] He stated that:

> "*We would not put a pilot in the cockpit without extensive flight training; why would we expect someone with no IT experience to be close to successful? They do not know what to execute on or what to prioritize which leads to endless risk reduction efforts and diluted focus. IT is a highly skilled and trained job; staff it as such*."[265]

The military digital factories all had leaders with extensive backgrounds in IT and Data Science. If not, they were from an operational background with education in STEM and supplemented with extensive technical acumen and understanding. To clarify, technical knowledge does not refer to "hands on keyboards" abilities only, but to the overall understanding of the concepts behind data analytics, software development practices, and

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[263] Anusha Dhasarathy, Ross Frazier, Neufal Khan and Kristen Steagall, "Prioritizing technology transformations to win", *McKinsey Digital*, last updated 24 March 2022. https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/prioritizing-technology-transformations-to-win?fbclid=IwAR184JTAQDdafT0Gq2-tuINqUROjUi442J9mqPd08yQtJnA2FoPLIUpDgwE

[264] Gareth Corfield, "USAF Air Force Chief software officer quits after launching Hellfire missile of a LinkedIn post at former bosses," *The Register*, 3 September 2021. https://www.theregister.com/2021/09/03/usaf_chief_software_officer_quits_angry_post/

[265] *Ibid*

the various platforms supporting such efforts. Moreover, technical knowledge was observed from the product owner (captain rank) up to the director level (col rank), and across trades; but the expertise must go both ways in which technical leaders must develop their operational knowledge to properly employ the technology.

Operations and Enablement

As in any organization, digital factories are highly dependent on funding, contracts, recruiting of talent, and other enabling functions. A robust leadership team will have additional staff that will support the synchronization of activities, solve bureaucratic dependencies, and conduct the day-to-day running of operations. Based on lessons-learned from the use cases, contracting and recruiting are two functions that are time intensive, and that can make or break the digital factory.

Architecture Committee

Too often, implementation of systems is conducted in silos by project groups that favour specific technology, leading to long-term technical debt. As a result, architecture becomes more complex to support, and more costly to sustain. As the digital factory grows, an architecture committee should be established to synchronize technical decision-making across teams and initiatives. The architecture committee should be composed of a designated member across the specialties (i.e., IT Infrastructure and Cloud, Data Architecture, Application Development and Cyber Security). When consensus cannot be achieved, the Director of Technology will have the final say.

The Programs

The programs are a line of effort that should focus on a specific value stream. The programs can be focused on a specific military function (Ops, Int, HR, Supply Chain, etc.)

or on a specific platform. This paper recommends the best approach, if resources permit, is to focus on specific functions as it provides a unifying purpose. Moreover, programs based on function enable decentralized prioritization. Smaller digital factories may not be able to separate programs that way and may need to align around capabilities. Thus, prioritization of use cases must happen at a higher level and require better integration across capability teams.

Programs will be overseen by program managers, which is well suited for military members due to their strong understanding of the business. However, at the infancy of a digital factory, there are benefits to hiring experienced program managers and product owners from the private sector to mentor and train junior members. Experienced contractors will allow for a quicker implementation of agile product management methodologies. The downside is that private-sector product owners may never fully understand the intricacies of the military environment, process, and terminology. Thus, the military should aim at developing a proficiency in that domain for the longer term.

Core Dev Teams

The core teams consist of the agile dev team that support the app development across their respective lines of effort. The teams should be built around problems as they will lead to the development of valuable products. Dev teams can be fixed or flexible. Flexible dev teams are supported by the surge of specialized team members (such as analytics and data engineering) when required. However, this requires the product owner to negotiate resourcing for its product. This leads to some companies working with "development credits" in which the product owner requests resources for a specific sprint. However, the downside of the flexible format is the potential impact on product continuity

as various product owners may fight for the same technical resources, especially in cases of highly unique skill sets. Moreover, it is more difficult for product owners to get dedicated access to specialized resources since they may support multiple products.

As part of the core team, you have the following roles:

1. Product Owner – The one who defines the features and the prioritization of the backlog.

2. Scrum Master – The one that conducts the synchronization of technical efforts on a day-to-day basis. Often this person is a senior developer.

3. UX designer – This person focuses on the design of the application from a user-interaction standpoint. In other words, they will "determine how the product will look and how it will work."[266] The UX designer attempts to make the software intuitive for the user by leveraging a human-centric approach.

4. UI designer – This person develops the graphical design of the application's user interface. This role requires high artistic creativity as it will make the application attractive and modern.

5. Front-End Developer – This person was previously known as the web developer. They implement the code behind the interface in which the user will interact.[267] They execute on the drawing and design of the UX and UI designer.

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[266] Andrew Burak, "What Agile Software Development Team Structure Looks like," *Relevant Software* (blog), last accessed 02 May 2022, https://relevant.software/blog/what-agile-software-development-team-structure-looks-like/.

[267] Michael Whales, "3 Web Dev Careers Decoded: Front-End vs Back-End vs Full Stack." *Udacity* (blog), last updated 1 July 2021. https://www.udacity.com/blog/2020/12/front-end-vs-back-end-vs-full-stack-web-developers.html

6. Back-End Developer – This person develops the software features and functionality that the user cannot see directly.[268] They will code all the features that will collect, move, and store the data for the application. However, back-end developers and data engineers should not be confused as the same role. The former focuses on the mechanics of the application, whereas the latter works on the data architecture and pipeline.

7. Business Analyst. This person provides the immediate customer feedback on the usability of the application, as well as provides more knowledge on the business processes and a profound understanding of the data.

Specialized Team

The specialized team allows for the unity of effort on initiatives and technical projects that support the overall development effort. These teams will centralize skillsets of the same subspecialty that can either work on projects within their team or in support to a core dev team.

Quality Assurance and Testing Cell[269]

This team specializes in the detection of bugs, defects, or errors as part of the code. Moreover, it also investigates the usability of the application to ensure that it does what it is supposed to do. The QA team will also include QA engineers, whose role is to develop test automation as part of the CI/CD pipeline. As small digital factories are often limited in

[268] Andrew Burak, "What Agile Software Development Team Structure Looks like," *Relevant Software* (blog), last accessed 02 May 2022, https://relevant.software/blog/what-agile-software-development-team-structure-looks-like/.

[269] Altexsoft, "Quality Assurance, Quality Control and Testing – the Basics of Software Quality Management," last accessed 02 May 2022, https://www.altexsoft.com/whitepapers/quality-assurance-quality-control-and-testing-the-basics-of-software-quality-management/

resources, QA should initially be centralized and in a supporting role across dev teams. As the organization grows, some programs should get QA specialists assigned to their core team.

Data Analytics Cell

This team focuses on the development of analytics products for decision-making, either independently or in partnership with the program dev teams. These teams produce standard descriptive analytics dashboards and analytics reports. They can also act in a role of support to decentralized analytics teams across the organization. Moreover, the data analytics team has a crucial role in delivering "quick wins" that help maintain leadership support for the digital factory.

The data analytics cell, which also includes data scientists, focuses on "hack-a-thon" type of problems that fit within the space of predictive and prescriptive analytics. Leveraging the data science process and using artificial intelligence techniques, its contribution can translate into the development of advanced analytics products. It can also support the building of permanent products within a line of operation. Data analysts and data scientists are often used in support roles across the various programs.

Data Engineering Cell

The data engineering cell includes the data architects, data engineers, and database administrators who oversee data movement across the infrastructure. They are responsible to design, build, and support the collection, processing, and aggregation of data to make it accessible to users as well as the development teams. The data engineering team also focuses on performance optimization, which is crucial with big data challenges and with the use of resource intensive AI algorithms.

Platform Team

The platform team installs, configures, and maintains the IT infrastructure, cloud services, and the DevSecOps tooling in support of the digital factory. The platform team is composed of various architects, DevSecOps engineers, cloud engineers and system administrators. These are also responsible for the integration of the tool and the automation of processes within the CI/CD pipeline. The platform team is also responsible to oversee the deployment of applications into production. The difference between an IT team and a platform team is that the IT team supports the data centre infrastructure and enterprise applications, whereas the platform team focuses solely on the enablement of the digital factory development efforts.

Talent and HR

The Rockstar

There is consensus across the interviews that the quality of the product managers and developers are what makes the difference. Contrary to other sectors where the "rockstar-performer" can increase productivity by 2x, the most proficient programmers can increase value by 10x – 100x times or more.[270] This concept is what drives the success of some of the biggest tech companies such as Google, Apple, and Netflix.[271] Reed Hasting, the co-founder of Netflix, uses the analogy of the ice-cream scooper.[272] The best ice-cream scooper can assemble 2-3 x the number of cones compared to the average person . But in software, the most creative and performing engineer can revolutionize the business, bring

[270] Reed Hastings, "Netflix CEO on paying sky-high salaries: 'The best are easily 10 times better than average,'" *CNBC Make It,* 8 Sep 2020. https://www.cnbc.com/2020/09/08/netflix-ceo-reed-hastings-on-high-salaries-the-best-are-easily-10x-better-than-average.html

[271] *Ibid.*

[272] *Ibid.*

millions of new customers, and provide value that hundreds of average programmers would not be able to. Moreover, the more complex the task, the wider the gap is between the rockstar and the average performer.[273] This is especially important when building software-at-scale where the number of users and the volume of data to be processed increase exponentially. In artificial intelligence, the best architecture design and the most optimized code can change whether you get the result of data queries in seconds versus days. Therefore, digital factories must be on a quest to find the "rockstar" talents and pay the appropriate wage to attract them.

The mention of the "rockstar" talent was recurrent, are most likely to come from the private sector, and to join the digital factories as contractors[274] since finding very high-performing talent is scarce.[275] To achieve the level of proficiency, breadth of experience, and technical mastery of these rockstars would require the best military technical talent to be employed for years in technical roles. Unfortunately, the military career progression and management plan does not allow for such a format, especially considering that top-level technical talent is expensive. The tech sector provides salaries in the range of 250k to 500k for their senior and most proficient developers, engineers, and scientists.[276] However, the high-range salary of the rockstar is considered quite cheap in comparison to the value they bring to an organization.

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[273] Scott Keller, and Mary Meaney. "Attracting and retaining the right talent." McKinsey & Company (2017).

[274] Former Global Analytics Platform Director, MS Teams interview with author, 19 Jan 2022.

[275] Scott Keller, and Mary Meaney. "Attracting and retaining the right talent." McKinsey & Company (2017).

[276] Business Insider. "Big Tech salaries revealed: How much engineers, developers, and product managers make at companies including Apple, Amazon, Facebook, Google, Microsoft, Intel, Uber, IBM, and Salesforce.", last updated 28 Apr 2022. https://www.businessinsider.com/tech-engineer-developer-salary-google-amazon-microsoft-ibm-apple-intel-2021-6

On the other hand, digital factories do not only require top-tier talent to achieve success. They require driven junior or mid-range developers to enable the complementary roles. To leverage a hockey analogy, for every Sidney Crosby, you require a talented player to be able to pass the puck, and you need a "goon" who will protect the top player. In software, the situation is similar. Top talent will tackle complex problems, but there are still the redundant and mundane development tasks that are required. Effective digital factories ensure that top talent does not work on the tasks that entry-level talent can perform.

Unfortunately, executive management and military leadership can be vulnerable to misrepresentation. Evaluating skill sets requires strong technical understanding, and until there is a core team of top-tier talent in the organization to evaluate and assess technical competencies, the organization will be vulnerable. Hence, every digital factory should have a robust recruitment process to ensure that the cost associated with the talent resource matches the right level of proficiency in their field of expertise.

The same issue applies to technology. Many companies will attempt to sell "shiny sparkles and rainbows" with demonstrations that captivate the imagination. These products can be perceived as extremely complex but are in fact quite basic. Having a diverse team in terms of skill set, background, and experience will reduce this vulnerability.

The Military Member

> "*We know how to build and run software businesses, but you guys are the only ones who know how to conduct military operations. Without tight integration with military members, we are just a pet project shop.*"
>
> – Serial Tech-Entrepreneur and GradA team member.

A military digital factory requires military members to achieve success. The military has a talent pool that can be employed across various roles. Depending on their technical and operational background, they can serve as program and product management, data analysts, or software developers. They have, in general, a better understanding of the user needs, which help translate how technology can be applied to military problems.[277] They understand the context of the data, they understand the process, and can provide immediate quality assurance feedback on tool usability.

Moreover, military members with strong technical backgrounds can be integrated as part of development teams to fill the role of junior and intermediary developers. They can deploy on missions, which will be key in the deployment of app development and analytics capabilities overseas. They can develop rapid prototypes which can be re-developed into more robust enterprise capability later. Snehal Antani, former JSOC CTO, argues that the current military system needs an overhaul to enable the young military graduates to capitalize on their education and contribute to mission-focussed problems in ways that industry cannot.[278] The military tech talent pool exists, but it needs support to flourish. Technical careers need to be reviewed and overhauled to enable a long-term transformation strategy, as the CAF can't depend solely on industry.

The Public Servant

The public servant is the continuity in the team. For every team in the digital factory, there should be at least one public servant. Contractors are at higher risk of

[277] Former Global Analytics Platform Director, MS Teams interview with author, 19 January 2022.

[278] Snehal Antani, Linked In Contribution, 02 May 2022. https://www.linkedin.com/posts/snehalantani_to-win-the-next-war-the-pentagon-needs-nerds-activity-6927030972202844163-DeRR?utm_source=linkedin_share&utm_medium=member_desktop_web

turnover due to other opportunities in the private sector, or gaps in contracts due to the procurement process. Therefore, hiring public servants enables the government organization to (1) develop long-term technical expertise, (2) provide continuity to support and maintain capabilities in the event of contract issues or unexpected departure, and (3) provide organizational knowledge on government IT system policies, processes, and procedures.

The Contractor

Most of the technical workforce will come from the private sector. It is a relatively rapid mechanism to recruit specialized skills across the various subspecialties of IT, software development and data analytics.

Retention

From the GAP experience, retention and turnover vary for both contractors and the civil service. "Some of them do barely 2 years whereas some do more than 7 years".[279] There is an accepted reality that contractors will go to other things every few years. Nevertheless, they also believed that turnover was healthy as it allows contractors to upskill their game by going to big high-tech companies before returning to the program. Although the pay may be lower within a governmental digital factory, the highly positive experience re-attracted some of the same talent after a few years away.[280] One of the biggest factors of turnover is bureaucratic friction within government, especially that related to the Dev and IT relationship.[281] As discussed, the ability to rapidly deliver code is a key principle.

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[279] Former Global Analytics Platform Director, MS Teams interview with author, 19 January 2022.

[280] *Ibid*

[281] Global Analytics Platform Talent Recruiter, MS Teams interview with author, 1 March 2022.

A highly proficient contractor can be driven outside of the organisation out of dissatisfaction when faced with recurrent obstacles to push code from development to production.[282] Thus, to retain the proper talent, a digital factory must be enabled with the proper infrastructure and DevSecOps processes. If not already implemented, it should be prioritized upfront as the key objective.

Military retention is also a key issue for digital factories. Within the US model, military officers (Capt to LCol) working in these programs do not necessarily have a career progression that allows them to command or be promoted to higher ranks while employed in technical leadership roles.[283] The CAF also has the same issue where officers that want to develop their expertise in the data analytics and software engineering domains will have limited promotion opportunities if they decide to remain in technical roles. The former GAP director also believes that "programs like these give the military talent a transparent look into their real worth, and when compared to industry, the military has limited opportunity for them".[284] As digital factories attract some of the best and innovative talent[285], a lack of a retention strategy and proper opportunity will drive members out of the organization to the private sector.

Reservists and Veterans as a Talent Pool.

The digital factory should also leverage the reserve force as an entry point to find part-time talent either on Class A or Class B contracts. Based on the US experience, some reservists are highly interested in applying their skills to military problems.[286] The

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[282] Former Global Analytics Platform Director, MS Teams interview with author, 19 Jan 2022.
[283] *Ibid.*
[284] *Ibid.*
[285] Rohit Bhapkar, Erez Eizeman, Joao Dias, Irene Floretta, and Marta Rohr. "Scaling a Transformative Culture through a Digital Factory." *McKinsey Insights* (2017). 2,
[286] Global Analytics Platform Talent Recruiter, MS Teams interview with author, 1 March 2022.

reservists employed by the GAP came from very prestigious universities or companies. They were employed during their weekend military service and contributed by taking tasks from the backlog of the core teams. Thus, it really helped accelerate the velocity of the programs.[287]

Moreover, another area of opportunity is to use veterans as a source of talent. Like reservists, veterans have a strong overall understanding of the organization, terminology, and methodologies. As an additional benefit, veterans tend to be less dissatisfied by the bureaucratic hurdles than the private sector technologist.[288] Additionally, the hiring mechanism within the government is extremely slow largely because of the security clearance process, but is less of an issue for veterans since they previously or currently possess one.[289] However, it is important to note that hiring veterans is not a panacea to staffing a complete digital factory because their technical skills will mostly range in the junior to intermediate level. Junior coders are highly creative and are good at developing a prototype that is "hacky". However, to develop enterprise grade software that can scale, it requires a level of expertise that is mainly developed within the tech companies in the private sector.[290]

Sourcing Talent

Finding talent to staff the digital factory is one of the biggest challenges. Besides the establishment of conventional contracted services mechanism such as Task-Based

[287] Former Global Analytics Platform Director, MS Teams interview with author, 19 Jan 2022.
[288] Global Analytics Platform Talent Recruiter, MS Teams interview with author, 1 Mar 2022.
[289] Global Analytics Platform Talent Recruiter, MS Teams interview with author, 1 Mar 2022.
[290] Former Global Analytics Platform Director, MS Teams interview with author, 19 Jan 2022.

Informatics Professional Services[291](TBIPS) and Temporary Help Services[292](THS), the CAF needs to establish strategic recruitment programs that can help source tech talent within government and industry.

The US Department of Defense understood the need for such recruitment and established multiple programs to attract young talent from universities as well as programs to train and hire veterans back into the government.

In August 2021, the U.S. Digital Corps was created to accelerate the entry of early-career technologists into the public service.[293] This program also emphasized the need for equal opportunity and diversity throughout the recruiting process, promoting a more inclusive approach to staffing their digital transformation talent.[294] Another initiative is the Defense Digital Service (DSS) which acts as "a rapid response team that includes top engineers, data scientists, product managers and designers" to surge into defence organizations and solve complex problems.[295] These "digital task forces" are sourced from the military, academia, and industry[296]. They are also leveraged as a pool of talent and a recruiting mechanism.

Another approach is to leverage non-profit organizations. The benefit of non-profit programs is that their incentives are not tied to the ability to fill positions to make profit on contract margins. The US has an extensive network of non-profit organizations that supports the training and placement of veterans and their spouses into the tech sector. An

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[291] Public Services and Procurement Canada, "Task-Based Informatics Professional Services", last accessed 02 May 2022, https://www.tpsgc-pwgsc.gc.ca/app-acq/sptb-tbps/index-eng.html.

[292] Public Services and Procurement Canada, "Temporary help services", last accessed 02 May 2022, https://www.tpsgc-pwgsc.gc.ca/app-acq/sptb-tbps/index-eng.html.

[293] United States Digital Corps. Last accessed 03 May 2022, https://digitalcorps.gsa.gov/about/.

[294] *Ibid.*

[295] Defense Digital Service, last accessed 03 May 2022, https://www.dds.mil/.

[296] *Ibid.*

example of such a program is Code Platoon which "helps veterans and military spouses transition into the civilian workforce by providing technical training and career placement".[297] They provide a 15-week curriculum, either full-time or part-time, and enable the opportunity to conduct an internship with corporate partners.[298] Another program is Operation Code[299], which aims at providing mentorship and support to veterans that want to transition.

In Canada, there are similar organizations such as Coding for Veterans which attempt to achieve similar goals and partner with universities to create a curriculum that makes their students attractive to industry.[300] An area of opportunity for the CAF is to act as an internship sponsor for students and provide them with an opportunity to work within the CAF digital factory as part of a core team. This would serve as an opportunity to scout talent as well as increase the overall pool of junior practitioners.

[297] Code Platoon, "About Code Platoon", last accessed 03 May 2022, https://www.codeplatoon.org/about-code-platoon/.

[298] Ibid

[299] Operation Code, last accessed 03 May 2022, https://operationcode.org/.

[300] Coding for Veteran, "What we Do", last accessed 03 May 2022, https://www.codingforveterans.com/.

CHAPTER 5: CONCLUSION

This paper demonstrated that the CAF needs to implement a digital factory to support its digital transformation ambitions, as well as to assure military competitiveness. However, this endeavour is difficult and involves risks to its success. Based on use cases of military digital factories within DoD and the CAF's own special forces, success is achievable by meeting specific conditions and making adequate decisions.

This paper started by providing a common understanding of what constitutes digital transformation. Being dependent on the ambitions of the organization, digital transformation objectives and lines of effort will dictate the type of emerging technologies to be adopted. This paper also explained the role of a digital factory and highlighted how the US DoD has been able to foster an ecosystem of insourced innovation to tackle challenging warfighting problems while saving tremendous costs. Their digital factory leverages emerging technologies in various areas such as data analytics and AI, big data, and cloud computing. It is also argued that successful implementation depends on a strong and robust investment in data architecture and related skills. Digital transformation and digital factories are dependent on a range of subspecialties working in concert.

Secondly, developing a strong, clear, and succinct strategy will be at the foundation of enabling success. It requires a vision, mission, and specific objectives that guide the organization's actions, activities, and decisions. Strategy cannot be everything, it must be unique and target a specific value proposition. The value proposition must have the warfighter in mind and be specific to something that will make the organization win against an opponent. Moreover, it is all about the trade-off between what the digital factory will and will not do. Achieving coherence will come from the choice of activities and lines of

effort that the organization will pursue. On the other end, a strategy is irrelevant if it doesn't help to achieve key successes within the first and second 100 days. Winning is all about gaining speed and maintaining momentum. Implementing a digital factory is a significant venture requiring tremendous change. Implementing lasting change requires a shared understanding within the organization, attaining speed of action, and ensuring to enable a critical mass of change agents. Conditional to successful change and innovation is the ability to support it with an agile structure. Hierarchical organizations are slow, favouring predictability. To succeed, a digital factory must operate in a dual operating system that enables start-up-like organizations, while still meeting the business' day-to-day needs.

Third, the digital factory must have a modernized culture and methodology to match the success of modern software development organizations. It must implement agile product delivery principles and DevSecOps practices to ensure the rapid, relevant, and secure delivery of new products to users. Moreover, it must be implemented in a way that can scale progressively as the digital factory gains experience and demonstrates value to both the customer and leadership. Simply increasing resources and funding without the proper expertise, leadership, and education will lead to failure. Moreover, agile must be enabled by proper tooling and infrastructure. The automation of the development and delivery process is essential; hence a tight integration of dev, security, and IT is required.

Fourth, this paper proposed a digital factory structure which includes the various teams and specialties required to achieve success. It needs a strong leadership team that covers the spectrum of operational understanding and technical knowledge. The structure must also be built around lines of effort to deliver relevant products to specific communities of warfighters such as Int, Ops, or Enterprise. These lines of effort, also named programs,

need support from various specialized groups such as quality assurance, data analytics, data engineering, platform, and cyber security. Working as a flat organization, resources need to be reallocated dynamically in support of program sprints.

Finally, the success of the digital factory is directly influenced by the quality of the talent that joins the team. The team must be composed of military members, public servants, and contractors. On the spectrum of knowledge, the military member brings operational insight, the contractor brings deep expertise, and the public servant brings continuity. However, knowledge is not monopolized by a certain group. The varying level of technical skills is unified through a flat organization, working towards the same goal. Unfortunately, the CAF digital factory will face challenges to source tech talent as the ecosystem of recruitment programs are limited in comparison to the US DoD.

Policy Recommendations

The CAF will face bureaucratic and cultural challenges to the implementation of the digital factory. The siloed approach to the distribution of authorities related to IT infrastructure does not permit the appropriate flexibility required for decentralized innovation. Agile and DevSecOps are disruptive for hierarchical organizations. Therefore, the DND and CAF digital transformation strategy must review the delegation of authorities across the various L1s, as well as the elements to support these goals.

Additionally, the CAF digital transformation strategy will require a deliberate mention of the enablement of digital factories across the organization and mandate support from the various functional silos (finance, procurement of goods and services, IT support, HR). Without strategic unified effort and agreement, the chance of success is low.

Finally, the CAF will need to review its trade structure to ensure the buildup of a digital talent pool within the military across data analytics, software development, and IT. Without internal expertise, the organization will remain vulnerable to third party and industry marketing tactics. Building internal expertise is the optimal approach to ensure that the digital transformation journey of the CAF remains under the control of the military instead of private companies. This will enable it to deliver products and technologies for operational outcomes.

Area for Further Research

This paper was mainly an overview of the foundational principles and concepts for the establishment of a generic digital factory, but more research can be performed to ensure its success and long-term viability. As use cases of digital factories within the public service are less than five years old, there isn't much literature on the best approaches. The short-term journey of such initiatives will be highly driven by trial and error, as well as imitation. Nevertheless, more research should be conducted on the procurement process, the workforce, and on public-private partnership.

First, the most important field of research related to digital factories, and innovation in general, relates to the modernization of the procurement system. Procurement processes and limitations were not addressed in this paper. However, it is one of the biggest bottlenecks to success. In the current system, it is extremely arduous for small tech companies to secure funding and contracts to support digital factories, although they could support the biggest disruption. Big defence companies have the monopoly on professional service contracts and are the only ones able to take the risk associated with long competitive procurement processes. Therefore, more research should be conducted on how to

modernize the procurement system, based on best practices, for the hiring of tech talent in the context of the digital factory.

Second, the military employment structure is not conducive to developing a digital military expertise within the CAF. Digital literacy and technical knowledge are not considered a prerequisite to occupy an institutional leadership position in the field of digital transformation. Moreover, military officers with a STEM background must decide early on in their career between becoming a specialist or a generalist. The former has limited opportunities for advancement in comparison to the latter. To compete in a technological age, the CAF must better manage the long-term potential and employment of STEM professionals. More research should be conducted on the trade structure of the CAF, investigate a structure of managed specialties, and develop a retention program targeted at attracting and retaining the digital workforce.

Finally, more research should be conducted on the best approach to conduct private-public partnerships for the establishment of digital factories. The research could investigate how the CAF can leverage resources and knowledge from academia, big tech, and crowdsourcing to work on challenging military problems. It should also investigate if the CAF digital factory should be a governmental entity, a privately owned organization, or a non-profit organization in support of military problems.

Final Thoughts

This research shows that digital transformation is hard and the probability of failure is high. Implementing a digital factory is a challenge, especially since it acts as a start-up within a rigid and hierarchical organization. Therefore, the CAF leadership must ask itself whether they are truly committed to this modernization or not, and if its current plan will

lead the organization towards success. As the future battlespace is happening now, every investment, every resource commitment, and every decision taken will shape the CAF's ability to operate and compete in this space for the next five to fifteen years. The biggest threat to CAF military supremacy in the battlespace is in fact, not doing enough. Peter W. Singer, a political scientist and researcher, stated that, historically, organizations and leaders have embraced change just enough to justify not changing their ways of doing things.[301] These organizations moderately invested in technology, changed policy without disrupting the status quo, and planned transformation over decades. This is a good reflection of the CAF's current state. Implementing a digital factory is a binary decision and a natural evolution of a digitalized military. The question is whether the CAF starts now, or in many years after its allies and adversaries have already implemented their own transformations. Nevertheless, answering this question is crucial since digital technology is a capability that will be required to win the next war. [302]

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