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Urgency for a CAF Strategic Renewal: A Case for Ambidexterity and Lean-Agile

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CANADIAN FORCES COLLEGE – COLLÈGE DES FORCES CANADIENNES

JCSP 47 – PCEMI 47
2020 – 2021

MASTER OF DEFENCE STUDIES – MAÎTRISE EN ÉTUDES DE LA DÉFENSE

URGENCY FOR A CAF STRATEGIC RENEWAL: A CASE FOR AMBIDEXTERITY AND LEAN-AGILE

By Major François Fortin

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ABSTRACT

What digitizing the force, a C4ISR spine, and a joint sustainment enterprise have in common? They are all the acting Chief of Defence Staff's "very high priority capability areas" and they are systems of systems (SoS). They are very high priorities because DND/CAF is late in the game of integrating those SoS. For example, C4ISR was first discussed in the mid-90s. Why DND/CAF struggles to develop SoS? This paper demonstrates that we are misaligned with the current technological and security environment and therefore applying the wrong strategy execution processes to integrate those capabilities.

In a complex environment, DND/CAF is required to become an ambidextrous organization, an organization capable of exploring innovation and solving complex problems while exploiting efficiently current technologies. Therefore, DND/CAF needs to tackle the integration of a SoS, a complex problem as defined in the Cynefin framework, and move it to simple procedures to be executed in the field, a tremendous challenge for a large organization.

In the current paradigm of capability development, mechanistic processes are used to solve complex problems resulting in the failure to successfully integrate SoS. This misalignment of processes with the environment is why DND/CAF struggles to integrate.

To re-align the execution processes with the environment, DND/CAF should implement key aspects of Lean-Agile: a role-based model that will ensure constant top and bottom alignment, a common cadence to enable integration touchpoints, and an organization structure based on the information-decision flow.

Those are widely known solutions tailored for the pace of change of the information age. This information age has started more than 20 years ago, at the same time that C4ISR started to be discussed. We do not have another 20 years to re-align our strategy execution processes before a major shift in the environment creates a disruption that DND/CAF is seldom ready to respond to. There is an urgency for a CAF strategic renewal.

INTRODUCTION

The *Pan-Domain Force Employment Concept* (PFEC) states what is widely known and experienced by CAF members: the capability development enterprise is not reactive and effective enough for the current technological and security environment. This environment is a blend of rapid technological changes adopted by friends and foes alike and an increased level of competition in the geopolitical sphere[1]. We can now add the uncertainty of the government's financial commitment to the defence program due to budgetary pressures caused by the pandemic crisis.

For the CAF to remain relevant in this environment, there is a wide consensus that the capability development enterprise needs to be streamlined. The Departmental Plan 2019-20 states that "[s]treamlined and flexible procurement arrangements ensure Defence is equipped to conduct missions."[2] In addition, scholars propose solutions coming from different angles: Richardson and al. from agile procurement[3], Taliaferro and al. from capability-based planning (CBP)[4], and Stone from the acquisition process[5]. The lead on the project management process, ADM(Mat), is also thriving for more agility. Agile procurement and DevOps are being looked at as probable solutions to increase agility. In some shape or another, they all acknowledge the need to change because of the rapid evolution of the environment.

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[1] Canada. *Pan-Domain Force Employment Concept*.
[2] Canada. *Departmental Plan 2019-20*, 35.
[3] Richardson and al. *Toward Agile Procurement for National Defence: Matching the Pace of Technological Change*. (Calgary; CGAI, 2020).
[4] Taliaferro and al. *Defense Governance and Management: Improving the Defense Management Capabilities of Foreign Defense Institutions: A Guide to Capability-Based Planning (CBP)*. (Alexandria, VA; Institute for Defense Analysis, February 2019).
[5] Craig Stone, *"Improving the Acquisition Process in Canada." (*University of Calgary, The School of Public Policy, SPP Research Papers 8, no. 16 April 2015*).*

These initiatives will not solve the problem because none of them embraces an end-to-end perspective of capability development. One of the telltale sign that a single approach will not solve the problem, is the failure of the CAF to produce a fully integrated and interoperable command, control, communication, computer, intelligence, surveillance, and reconnaissance (C4ISR)[6] system of systems (SoS) in the last 20 years. The Land Command Support System (LCSS)[7] is the main deployable C4ISR SoS used at the tactical/operational level. This is the SoS that is being designed to be interoperable with our NATO allies and that integrates the different tactical systems. It mainly failed because of the shortcomings in the 3i: institutionalization, integration, and interoperability. For example, only 15% of the systems of LCSS are institutionalized, i.e. the training, procedures, concepts of support, etc. are defined and available. Most of the non-institutionalized systems are not being used because users simply do not know they exist. Also, most projects are not taking into account the integration requirements other than by idiosyncrasy. Most projects are arriving at implementation without any integration considerations. For example, a recent project procured a sensor without taking into account the integration of this sensor to the C4ISR SoS, rendering this new capability useless for many years until a subsequent project that is constantly delayed is capable of integrating those requirements. Finally, interoperability with our allies is also a complex problem. Every member of NATO has their own SoS composed of more than

[6] This paper will use the C4ISR acronym to represent the SoS responsible to transfer, store, and process data in the battlespace. A characterization of the C4ISR SoS will be discussed in Chap. 2.

[7] As the LCSS Architect between 2016-18, I have mapped the main services on the LCSS to the systems in the baseline. With the help of training establishments and the different Centers of Excellence, I identified which systems were trained including continuation, regenerative and conversion training. I also investigated with LCMMs which systems were supported by them and if they knew their concept of support. Finally, I went to multiple coalition exercises to observe and evaluate the utilization rates of these systems. The main findings were that only 15% of the systems in the LCSS are used and most non-institutionalized systems were not.

100 major systems each. In any given year, half of those systems can be upgraded. Keeping the systems interoperable with our main allies is a moving target. Achieving interoperability needs a sensible investment into developing standards. Most of them are painfully slow to develop and barely abide to. This means that legacy systems need to be kept on the SoS in case an ally does not have an upgraded system. In parallel, major players such as the United States are accelerating the incorporation of new technologies in their C4ISR SoS, putting pressure on DND/CAF to "follow the leaders"[8]. With that complexity, if agile procurement succeeds, it will only add to the pressure on the 3i and augment the numbers of non-institutionalized, non-integrated, non-interoperable systems. This is also true for CBP or the acquisition process, better upstream requirements or faster approvals will not fix the 3i, on the contrary, it will overflow the mechanistic processes used to integrate and institutionalize capabilities. It does not mean that all those processes are not important wheels of the capability development machine. It means that they cannot be taken separately from the internal wheels and those internal wheels are what DND/CAF control.

The CAF is not the only organization facing this problem. The private sector has similar pressures. Some companies fail, others succeed because they adapted on time to an emergent context. However, DND/CAF evolves in a different environment, the public sector, where there are more structural constraints. Three different departments have competing priorities in the defence procurement process. It is possible that the Government of Canada (GoC) will create a new defence procurement agency. It is also possible it will help in the delivery of major projects, mostly high visibility projects such

[8] Richardson and al. *Toward Agile Procurement for National Defence: Matching the Pace of Technological Change*. (Calgary; CGAI, 2020): 3-4.

as the National Shipbuilding Strategy and the Future Fighter Capability Project. It is unlikely it will help in the procurement of volatile technologies because "the reasons [for these shortfalls] have much more to do with internal issues that have nothing to do with whether or not there is one agency responsible or three departments responsible."[9] Therefore, we will consider these structural constraints as a constant because it is unknown whether a new agency could positively affect the internal alignment and solving the 3i problem.

Organizations in both the private and public sectors are successful at solving the 3i problem. The Dutch Army developed in the past two decades a very effective C4ISR SoS by aligning their strategy execution processes with an end-to-end perspective using a Lean-Agile framework. However, for DND/CAF, the quest for agility is starting late and both the technological and the security environment are accelerating. Therefore, it is with a sense of urgency that DND/CAF leadership should realign the capability development enterprise.

This paper will demonstrate how DND/CAF could execute strategic processes that will realign the capability-development enterprise despite current exterior structural constraints. It will be done by an analysis of the current paradigm and the application of the Lean-Agile framework to the enterprise. Therefore, this paper will endeavor to answer the following question: within the constraints of the public sector, how the Lean-Agile framework applies to the DND/CAF capability-development enterprise?

This paper argues that DND/CAF fails at developing SoS because there is misalignment between the complexity of the environment and the strategy execution

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[9] Stone, J. Craig. *A Separate Defence Procurement Agency: Will it Actually Make a Difference*. (Calgary, Canadian Defence & Foreign Affairs Institute and Canadian International Council, February 2012), 15.

processes and proposes that DND/CAF becomes an ambidextrous organization by applying key elements of Lean-Agile. Chapter 1 will present the theoretical foundation of this thesis. We will present the Cynefin framework as a sense-making construct that will help us understand contextual alignment and multi-level alignment. From there, conclusions will be drawn on how ambidexterity marries with the Cynefin dynamics, demonstrating that ambidexterity is the capability of an organization to move between the ordered and unordered domains. This movement is key to survive and thrive in a complex security and technological environment.

Chapter 2 will present the drivers for change, the complexity of the environment. Two factors of complexity will be discussed, the requirement for threat-based planning and the integration of SoS. Both are expression of the complexity of the security environment and the complexity of the technological environment respectively.

Chapter 3 analyses the current paradigm and draws conclusions on how DND/CAF is currently aligned with its context. Strategy execution processes for each level of the capability-development enterprise are presented and characterized.

Finally, Chapter 4 recommends the use of key elements of Lean-Agile that will enable DND/CAF to become an ambidextrous organization and successfully align the strategy execution processes with the environment.

CHAPTER 1: STRATEGY, COMPLEXITY, INNOVATION, AND AMBIDEXTERITY

> [W]hen the means match the context, less energy need be expended for the same result.
>
> – Kurtz and Snowden, "The New Dynamics of Strategy"

On October 29th, 2020, the Vice-Chief of Defence Staff (VCDS), Lieutenant-General Rouleau, sent a letter to the capability development community[10]. This letter skillfully presents the problem set, clearly stating the challenges of developing capabilities for a Pan-Domain environment. In his letter, the former VCDS touches on many themes: the importance of alignment, the need of disciplining the process of creating a SoS, and the requirement to integrate this SoS as a whole and not a sum of parts, including the integration of the enabling capabilities.

The VCDS, as the process owner of the Defence Service Programme (DSP), the portfolio of defence capabilities, is declaring, in his own words, the failure of the old way of developing capabilities. He specifically identified four priorities for his office that are deemed essential for the future of the CAF. In a message to the CAF, the acting Chief of Defence Staff, Lieutenant- General Eyre, maintained the same four priorities for capability development[11]. As part of his four priorities, the development of a C4ISR spine is the telltale sign of this failure: DND/CAF was incapable of developing a fully integrated and interoperable C4ISR SoS within the last two decades. As early as the 90s,

[10] Canada. Vice Chief of the Defence Staff. *Open Letter to the Capability Development*. (Ottawa, ON, 29 October 2020).
[11] Canada. Acting Chief of the Defence Staff. *Acting Chief of the Defence Staff Focus Areas.* (Ottawa, ON, 25 March 2021).

the idea of Network-Centric Warfare (NCW)[12] and a supporting C4ISR SoS[13] popularized to become the strategy for the information age. Failing to produce the C4ISR SoS leads to the failure of executing the NCW strategy.

The failure to execute a strategy is not a new problem. Between 60 and 90% of strategies fail during the execution process[14]. The literature on the subject identifies that alignment is the foundation of effective strategy execution[15]. The VCDS also mentioned the importance of alignment in his letter[16]. Srivastava and Sushil, in their review of literature on the subject, identify seven alignment factors that are considered by major authors as focus areas for successful strategic alignment: business units, resource commitment, policies, operations, structure, best practices, and community orientation[17]. The literature on strategy execution proposes multiple frameworks that delineate the process. These frameworks structure the seven factors and build a common body of knowledge that creates a known and understood solution for the organization. One of the best-known strategy execution frameworks is the Project Management Body of Knowledge (PMBoK), but there are many more. In a survey of 83 organizations, Busulwa and al.[18] identify twelve different strategy execution processes. Some are part of

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[12] David S. Alberts, John J. Garstka, and Frederick P. Stein, *Network Centric Warfare: Developing and Leveraging Information Superiority* (CCRP publication series, 2nd ed., August 1999).
[13] William H. J. Manthorpe Jr., "The Emerging Joint System of Systems: A Systems Engineering Challenge and Opportunity for APL" (*John Hopkins APL Technical Digest*, Vol. 17, Number 3, 1996): 307-8.
[14] Richard Busulwa et al. *Strategy Execution and Complexity: Thriving in the Era of Disruption* (Taylor & Francis Group, 2018. *ProQuest Ebook Central*, https://ebookcentral.proquest.com/lib/cfvlibrary-ebooks/detail.action?docID=5611518): 3.
[15] Amit Srivastava et Sushil, "Alignment: The Foundation of Effective Strategy Execution" (*International Journal of Productivity and Performance Management*, Vol. 66, Issue 8, 2017): 1046-1050.
[16] Canada. Vice Chief of the Defence Staff. *Open Letter to the Capability Development*. (Ottawa, ON, 29 October 2020): 1.
[17] Amit Srivastava et Sushil, "Alignment: The Foundation of Effective Strategy Execution" (*International Journal of Productivity and Performance Management*, Vol. 66, Issue 8, 2017): 1047.
[18] Richard Busulwa et al. *Strategy Execution and Complexity: Thriving in the Era of Disruption* (Taylor & Francis Group, 2018. *ProQuest Ebook Central*, https://ebookcentral.proquest.com/lib/cfvlibrary-ebooks/detail.action?docID=5611518): Chapter 3.

a codified framework and others are informal. From their study, we can draw two conclusions. First, different levels require different execution processes. For example, Letens and al., in their review of literature on product development, identified three levels: portfolio, project, and functional[19]. Depending on the organization, each level of product development would have a different execution process such as a stage-gate process at the portfolio level, PMBoK at the project level, and service management at the functional level. We will further develop on the capability development levels in chapter 3. In military planning, the strategic, operational, and tactic levels are the levels used to execute a strategy. Each of those levels has different execution processes such as the battle procedure at the tactical level and the operational planning process at the operational level. The key to proper alignment is the selection of the appropriate execution process at the right levels.

Second, the complexity factor is primordial to determine the type of strategy execution process required by the organization. This is the essential finding of Busulwa and al. because it includes the environmental context in our understanding of strategy execution[20]. Therefore, in a volatile market, where rivals strive to develop disruptive technologies, the organization will not survive if it does not apply an appropriate strategy execution process[21]. In that regard, when he was VCDS, LGen Rouleau established the Pan-Domain as the baseline for force development in the CAF: "It is not debated that we face a 'Pan-Domain' future in conflict terms. This means adversaries will seek to

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[19] Geert Letens, Jennifer A. Farris, and Eileen M. Van Aken, "A Multilevel Framework for Lean Product Development System Design" (*Engineering Management Journal*, Vol.23, No. 1, March 2011): 69-72.
[20] Richard Busulwa et al. *Strategy Execution and Complexity: Thriving in the Era of Disruption* (Taylor & Francis Group, 2018. *ProQuest Ebook Central*, https://ebookcentral.proquest.com/lib/cfvlibrary-ebooks/detail.action?docID=5611518): Chapter 3.
[21] Steve Blank, interview by Frieda Klotz, "Why Large Companies Struggle With Lean" (*MIT Sloan Management Review*, 2019)

simultaneously over-load Western militaries with friction across the maritime, air, land, cyber, space and informational domain."[22] The Pan-Domain is thus the newly formulated CAF strategy and it describes a complex environment dominated by state competition and rapid technological innovation. Are the current CAF strategy execution processes aligned with this new strategical context at all levels?

The CAF failed to effectively execute the NCW strategy because of a lack of alignment between the context and the different execution levels in the organization. With the new pan-domain strategy being stated, the CAF must re-align its execution processes at all levels to match the level of complexity of the security and technological environment. In this chapter, we will demonstrate that strategy execution processes need to be tailored to the context at all levels. We will first discuss the difference between strategy formulation and strategy execution, and the importance of multi-level alignment. We will then introduce the Cynefin framework as a model to understand complexity and finally, describe Cynefin Dynamics that enable the movement between levels of complexity.

Strategy Formulation vs Strategy Execution

"A mediocre strategy well executed is better than a great strategy poorly executed" is a common mantra[23]. In this, there is the accepted idea that strategy formulation and strategy execution are two different things: A great strategy could be poorly executed and fails. How is this possible? A failed strategy is a failure whether it

[22] Canada. Vice Chief of the Defence Staff. *Open Letter to the Capability Development*. (Ottawa, ON, 29 October 2020): 1.
[23] Roger L. Martin, "Drawing a line between strategy and execution almost guarantees failure", (*Harvard Business Review*, July-August 2010): 66.

was poorly executed or poorly formulated. None could know if a failed strategy was well formulated since it never came to fruition. There is a strong co-dependency between the two, formulation as the ends need to consider the execution as the ways and the means. Strategy formulation and execution are the two sides of the same coin. They are interrelated but separated only as an object of study[24]. Both Martin and Bulsuwa and al. agree that the relationship between formulation and execution is key[25] [26]. They both need to be aligned.

The second important alignment is between levels of the organization. Martin summarizes this alignment as a choice cascade. "Each set of rapids is a point in the corporation where choices could be made, with each upstream choice affecting the choice immediately downstream. Those at the top of the company make the broader, more abstract choices involving larger, long-term investments, whereas the employees toward the bottom make more concrete, day-to-day decisions […]"[27] This idea is similar to the set-based approach in product development[28], the Agile Manifesto that will be discussed in chapter 4, or power to the edge in military studies. The principle is the same: Higher management has to refrain from removing choices that could be done at a lower level. Therefore, in selecting the frameworks for strategy execution, there is an alignment principle to avoid killing choices too early in the process or too high in the hierarchy. This also means that complexity does not have to be tackled only at the higher level. In

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[24] *Ibid*.: 66-69.
[25] *Ibid*.
[26] Richard Busulwa et al. *Strategy Execution and Complexity: Thriving in the Era of Disruption* (Taylor & Francis Group, 2018. *ProQuest Ebook Central*, https://ebookcentral.proquest.com/lib/cfvlibrary-ebooks/detail.action?docID=5611518): Chapter 3.
[27] Roger L. Martin, "Drawing a line between strategy and execution almost guarantees failure", (*Harvard Business Review*, July-August 2010): 69.
[28] For an excellent review of literature on set-based design: Boris Toche, Robert Pellerin, and Clement Fortin, "Set-based design: a review and new directions" (*Design Science*, Vol. 6, 2018).

their strategic decisions, higher-level management can identify specific sub-organizations tailored for disruptive innovation and complexity and other organizations that will aim to reach simplicity and efficiency. For example, the CAF needs the bulk of its forces to follow clear standing operating procedures (SOPs) and another part to fight in niche environment using unconventional means. It also requires to move its tactics and procedures from complexity at the strategic level to simplicity at the edge, the tactical level. Therefore, the multi-level alignment is taking its source from a context; it delineates parts of the organization that will evolve in different contexts requiring different ways and means to execute the strategy; and it is capable to move from complexity to simplicity at the appropriate levels to be successful.

Both contextual alignment and multi-level alignment are important factors to successfully align formulation and execution. This does not mean that the seven factors enumerated by Srivastava and Sushil are unimportant. On the contrary, they are complementary. Structure and processes need to be aligned, orientation is given, best practices followed, etc. However, in the development of a C4ISR SoS, as stated by the former VCDS, the context (Pan-Domain) matters. Therefore, the key to a successful strategy alignment starts with understanding the context, to make sense of the context.

Introduction to Cynefin

Kurtz and Snowden introduced in 2003 the Cynefin framework[29].The Cynefin is a sense-making framework that sorts "issues […] into five contexts defined by the nature

[29] C.F. Kurtz and D.J. Snowden, "The new dynamics of strategy: Sense-making in a complex and complicated world" (*IBM Systems Journal*, Vol. 42, No. 2, 2003): 462-483.

of the relationship between cause and effect."[30] It is widely used in the business world or in the defence community such as in the US military to understand the question of complexity in an environment and how it relates to decision making. Therefore, Cynefin proposes a construct that aligns decision making with its context. In this section, we will present the Cynefin framework as the tool to understand the context, a key element to

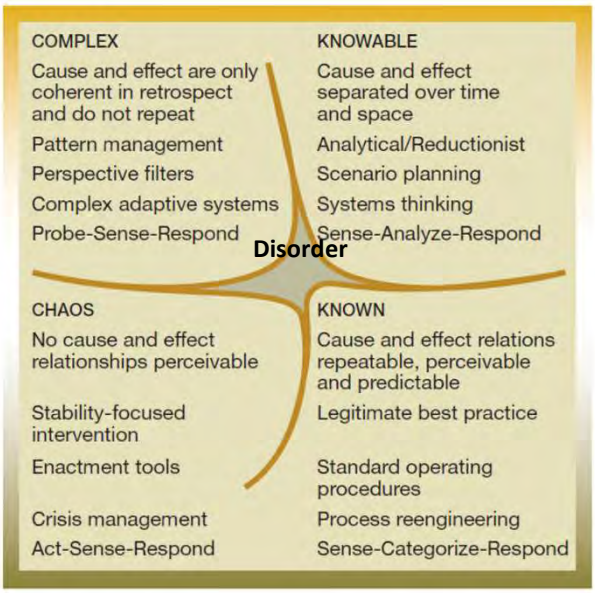

Figure 1: The Cynefin Framework

Source: C.F. Kurtz and D.J. Snowden, "The new dynamics of strategy: Sense-making in a complex and complicated world" (*IBM Systems Journal*, Vol. 42, No. 2, 2003): 468.

execute a strategy. The Cynefin divides knowledge between two ordered domains, two unordered domains, and disorder as shown in figure 1. The first ordered domain is the 'Known causes and effects' or simplicity. Linear, repeatable, and predictable processes manage this domain. In this domain, managers will seek to gain efficiency, as the process is simple to understand and its efficiency, easy to measure. Decisions are based on the Sense-Categorize-Respond model, meaning that once new information is received, it is

[30] David J. Snowden and Mary E. Boone, "A Leader's Framework for Decision Making" (*Harvard Business Review,* November 2007): 70.

categorized based on best practices and responded based on standing operating procedures. All of those are highly trainable to line workers that execute the process based on measures of performance. This is a highly structured domain, where authorities, responsibilities and accountabilities are clearly defined between functional teams. For example, a call center operates in this simple domain area. Tickets are received, processed, and stored. Agents performance is measured based on clear metrics.

The second ordered domain is the 'Knowable causes and effects' or complicated. This is the domain of the experts and system thinking where the power of analysis enables the understanding of the object to a point where, with enough time and resources, the object could become known. However, most of the time the object remains known only to the experts. Scenarios help to test the hypothesis. Decisions are based on the Sense-Analyze-Respond model, where new information, often partial, is tested based on assumptions. A scientific methodology is used to analyze the data of experiments that confirm the hypothesis. Experts will then provide courses of action that can be presented within a roadmap with clear objectives and desired outcomes. Any given organization typically has both, simple and complicated frameworks. Most of the time, higher and mid-level management try to distill complicated issues into simple tasks. A good example of a framework in the complicated domain is the operational planning process (OPP) in the CAF. The OPP is heavily inspired by the scientific method. In establishing planning hypotheses and performing mission analysis, the staff is following a deductive method that leads to the presentation of courses of action (COA) to the commander. The COAs presented are all valid and functional, therefore all good solutions. They are compared to each other using a quantitative method that weights each COA based on factors drawn from the commander's intent. The OPP will lead to the emission of orders which is the

movement from complicated to simple so tasks are eventually clearly assigned to a group of soldiers that can follow SOPs to achieve them. In sum, the complicated domain still has causality and predictability once the subject is studied in depth. When causality and predictability is undiscoverable, we tip into the unordered domain, the domain beyond rationality.

The first unordered domain is ‘Complex relationships’ or complexity. “This is the domain of complexity theory, which studies how patterns emerge through the interaction of many agents. There are cause and effect relationships between agents, but both the number of agents and the number of relationships defy categorization or analytical techniques.”[31] In other terms, the causes and effects are unfathomable for human cognition because of the vast number of variables in the equation. Only in hindsight that causes and effects can be understood without any guarantee that this particular causality is repeatable. Decisions are based on the Probe-Sense-Respond model. Probes are input in the complex system to find emergent patterns. The sense is possible through the lenses of multiple perspectives and a strong challenge function that allows a diversity of thoughts. For example, most human systems such as societies are complex. This is the domain where disruption emerges. To foster the emergence of disruptive innovation, there is the need to explore new solutions, to create the conditions of creativity. And these conditions can be created using the Probe-Sense-Respond model of the complex domain.

The last un-ordered domain is 'Chaos'. In this domain, human cognition cannot perceive the causes and effects. No system can structure this domain. It is the domain that is the best to foster disruptive innovation by the use of design thinking and the

[31] *Ibid*. : 469.

divergence-convergence technique. An organization would want to go to the edge of chaos to foster game-changing or disruptive innovation. It is also the domain of intuition and talent versus processes and efficiencies. However, for a large organization, it would be unfathomable to bring the whole organization to the edge of chaos. Therefore, only part of the organization can be brought there and successfully come back. Decisions are based on the Act-Sense-Respond model. For example, crisis are chaotic. They require a strong reaction to correct the situation (act), an evaluation of the situation (sense), and a tailored response based on the outcome of the action. The unordered domains are different from disorder. Disorder is when it is uncertain or contested which Cynefin domain applies. For example, leaders disagree if the context is complex vs complicated creating a disordered response and the potential for catastrophic events.

The Cynefin framework is helpful to understand the contextual alignment of the strategy and can also help to determine the multi-level alignment in a perspective of a large organization such as DND/CAF. For example, innovation in artificial intelligence (AI) stagnated until 2012, when a major breakthrough occurred in deep machine learning[32]. This major breakthrough is a disruptive event in the market and the military operational environment. Therefore, this new context in AI demands a new strategy to counter potential AI threats and possibly gain a competitive advantage in this domain. Because the future application of deep machine learning is still largely unpredictable, the strategy execution process to develop future AI capabilities will resemble something in the domain of chaos and complexity. Using a mechanistic process tailored for the ordered domains such as project management or the waterfall method in system engineering, is

[32] Bryan House, "2012: A Breakthrough Year for Deep Learning", last modified 17 July 2019. https://medium.com/limitlessai/2012-a-breakthrough-year-for-deep-learning-2a31a6796e73.

not reactive enough to the current innovative environment in AI. However, some very practical AI innovations are already in use. The exploitation of those innovations is closer to the complicated-complex domains and would require a different alignment of the strategic execution processes. Eventually, the practical use of AI in the field will require to be simple. Soldiers will need specific procedures to operate an AI-enabled system.

The question is then: How to bring a complex problem to become simple enough that it enables the strategy to be executed with success? If 60 to 90% of the strategy fails during execution, we posited that it is mainly because they fail to align to the Cynefin domains at each level. As stated earlier, it does not mean it is a decrescendo from complexity to simplicity. Some specific teams can be tackling a complex problem, but eventually, the problem will need to be simple enough so line workers or troops in the field can execute the strategy. How an organization can move across the boundaries of the Cynefin domains, between chaos and complexity, between complexity and complicated, and between complicated and simple? One less-known aspect of the Cynefin framework is the cross-boundary dynamics (Figure 2).

Cynefin Dynamics

Understanding how to move between the domains is as important as understanding the domains themselves. The best way to comprehend these dynamics is to view the flow between information and decision in the system, where information "is formed by selecting, organizing and summarizing data to be meaningful and useful within a specific context."[33] Information is therefore contextual. In general terms, it also

[33] S. French, "Cynefin, statistics and decision analysis" (*Journal of the Operational Research Society*, no. 63, 2013): 553.

percolates from the bottom to the top of the organization. The information gathered helps to make decisions that generally move from the top to the bottom of the organization in a cascade of choice. Therefore, the multi-level and contextual alignments are closely knit to the information-decision flow of the organization.

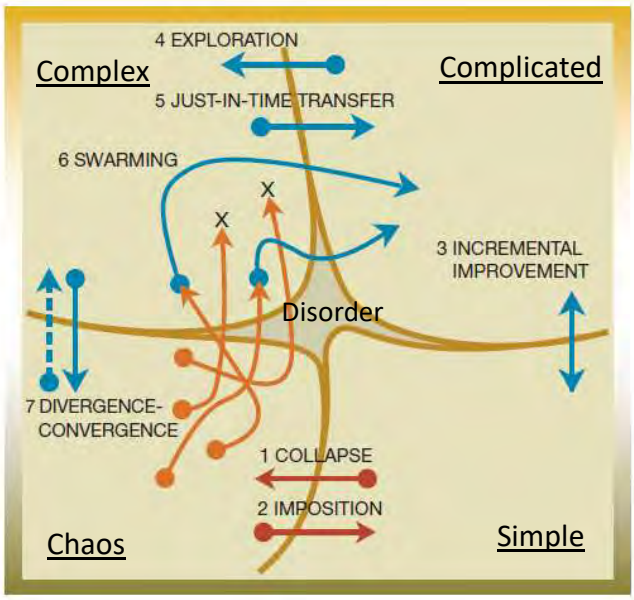

Figure 2: The Cynefin Cross-Boundaries Movements

Source: C.F. Kurtz and D.J. Snowden, "The new dynamics of strategy: Sense-making in a complex and complicated world" (*IBM Systems Journal*, Vol. 42, No. 2, 2003): 476.

The movement between simple and complicated is done by incremental improvements (Item 3 in Figure 2), where the cycle of information will dictate the length of the increments. The increments are information-decision cycles themselves. For example, in the development of software, users do not know at the beginning all the requirements. They know they have a problem, they require efficiency for example, but they do not comprehend yet all the second and third orders of effects of their problem and, therefore, cannot articulate their requirements fully. The development team will start with small increments of development and will present after each increment part of the

solution that will trigger better-defined requirements, etc. In sum, the movement between complicated and simple and vice-versa is characterized by increments based on the fidelity of the information available to make a decision.

In that sense, each increment provides more fidelity to the prior knowledge (called posterior probability in the bayesian decision theory) until an acceptable level of fidelity is achieved[34]. The key here is a probable causal link needs to be known before incremental improvements can be supported. If the initial premise is wrong (the prior), then the foundation of the improvements is weak and will most likely fail. Therefore, from a Cynefin perspective, to execute a strategy with an incremental improvement framework, the premise, in this case, the context, needs to have a probable degree of certainty. At the moment the strategy is nested in a context of high uncertainty and low granularity of information, then the context is complex and evolves in different dynamics with a different logic.

The movement from complicated to complex is fundamentally different than incremental improvements because, in the complex domain, the information is unclear, the causality is undiscoverable, but in hindsight and not repeatable. Decisions have to be based on abductive reasoning versus deductive and inductive reasoning for the ordered domains. In deductive reasoning, one starts by asserting the truth of the facts to establish that the conclusion is true. In inductive reasoning, some facts (4 out of 6 colleagues ordered the same sandwich) lead to a probable conclusion (the sandwich is good). In abductive reasoning, the effect is evident (the sandwich on the counter is partially eaten) and the most plausible explanation is drawn (your son was eating the sandwich but was

[34] Stanford Encyclopedia of Philosophy, "Baye's Theorem", last modified 30 September 2003. https://plato.stanford.edu/entries/bayes-theorem/.

late for class and never finished it)[35]. Therefore, in the complex domain, the decision-making process has to allow trial and error and exploration because the information is incomplete and fluid (item 4 of Figure 2). Eventually, patterns will emerge and be exploited (item 5 of Figure 2). For example, the different levers of the fiscal sector in macroeconomics (taxation, government spending, and transfer payments) are patterns that have been discovered by abduction and are used to control a complex system, the economy. These patterns are studied by experts (central banks) that neither fully comprehend, nor control all the mechanisms of the system. Therefore, there is always a risk that the internal mechanisms of the system change and the pattern is disrupted, plunging into chaos (economic crisis).

It is a crisis when the system is plunged into chaos versus deliberately going into chaos. The recent COVID-19 pandemic is a good example of the chaos-complexity dynamic. During the pandemic, the governments could not establish a clear way to manage the pandemic because of the paucity of our knowledge. Therefore, decision-making has to be made on intuition and past similar experiences. Because only decisive action enables the organization to leave the state of chaos, the leadership of many government officials was underlined during the pandemic as powerful attractors. However, each government made different decisions that were more or less successful. Therefore, there was a "swarm" of measures (item 6 of Figure 2), none establishing causal links with the diminution of infections. However, eventually, successful patterns emerged that, in hindsight, will demonstrate to be the right measures to fight the virus.

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[35] Merriam-Webster, "'Deduction' vs. 'Induction' vs. 'Abduction'", last consulted 5 May 2021. https://www.merriam-webster.com/words-at-play/deduction-vs-induction-vs-abduction.

Swarming is the natural reaction to chaos and the emergence of patterns is the sign that the situation has moved from chaos to complexity.

An organization could decide to move deliberately from complexity to chaos in a bid to foster disruptive innovation. Kurtz and Snowden explain that the divergence-convergence method of design thinking (item 7 of Figure 2) is an effective and controlled way to bring a focus group into chaos and back. The Divergence-Convergence method is illustrated by a double diamond shape (Figure 3). The first diamond is exploring an issue first by going wide (discover), then by going deep (define). The second diamond focuses on the action by developing a solution bringing in a large group with diverse and dissident perspectives (develop) and then, testing multiple avenues (deliver). The Divergence-Convergence method is based on people with multiple perspectives and trial and errors, also called abductive reasoning.

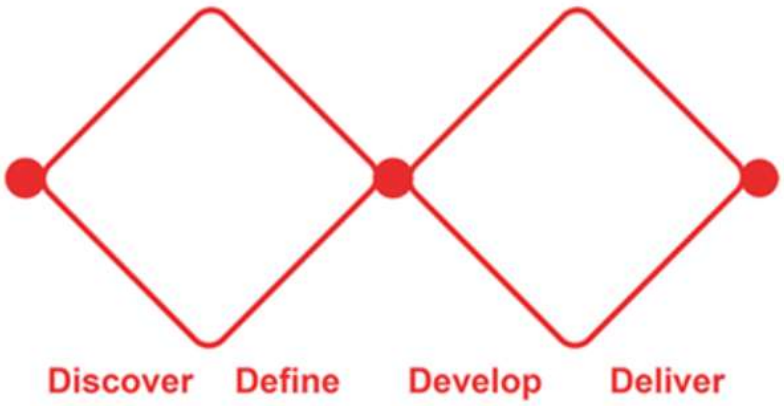

Figure 3: Divergence-Convergence

Source: Jasper Liu, "Visualizing the 4 essentials of Design Thinking", https://medium.com/good-design/visualizing-the-4-essentials-of-design-thinking-17fe5c191c22.

The last movement is catastrophic failure, where order plunges into chaos (item 1 of Figure 2). "Organizations settle into stable symmetric relationships in known space and fail to recognize that the dynamics of the environment have changed until it is too late."[36] In this case, stability becomes inertia. What made the organization successful in the past is its own demise, because structurally and culturally, decision-makers fail to take into account new information that the context has changed and rely on past successes, myths, and heroes to maintain the organization in inertia. Only decisive leadership can bring the organization back (item 2 of Figure 2). Leadership is the strong attractor to bring the organization back from chaos.

The Cynefin Dynamics are a construct that helps for decision-making when an organization needs to move an issue from one domain to the other. It both informs the organization how to execute a strategy and when to modify a strategy based on a change in the context. The differences between complicated and complex were specifically underlined. The reason for this is that this boundary is the most confusing for organizations. How can one know when it passes from the ordered to the unordered domain? For example, a catastrophic failure that brings an organization from simple processes to chaos is easy to identify. This is much harder to determine for the case of the complicated-complex boundary. The boundaries between the ordered and unordered domains have been studied from multiple angles. Management, engineering, history, and military studies have all approached the phenomenon with a different perspective such as crisis management and the history of catastrophes. However, in the context of innovation and capability development, one concept deepens our understanding of this boundary:

[36] C.F. Kurtz and D.J. Snowden, "The new dynamics of strategy: Sense-making in a complex and complicated world" (*IBM Systems Journal*, Vol. 42, No. 2, 2003): 475.

The concept of Ambidexterity which has been proposed by Charles O'Reilly from the Stanford Graduate School of Business and Michael Tushman from the Harvard Business School. Ambidexterity appears to provide a potential approach to solve this critical problem in SoS.

Ambidexterity

Ambidexterity is the quality of an organization to evolve in both the ordered and unordered domains of the Cynefin framework. The next paragraphs will explain how an ambidextrous organization can cross those boundaries as required.

Ambidexterity came from the observation that successful organizations can fail to adapt to emerging situations. This phenomenon is called the success trap, where established successful organizations failed to adapt to a shift in the market. One typical example of the success trap is the in-between Steve Jobs period at Apple (1991-1997). The major technological breakthrough that led to the creation of the personal computer was the invention of the microprocessor in 1972. The initial success of the MacIntosh was due to an energetic period of technological exploration illustrated by the first product innovation curb of Figure 4. In the MacIntosh, Steve Jobs created the best design of personal computer, the dominant design #1 in Figure 4. However, once the technology was out in the World, an iterative improvement cycle started, the first process innovation curb in Figure 4.

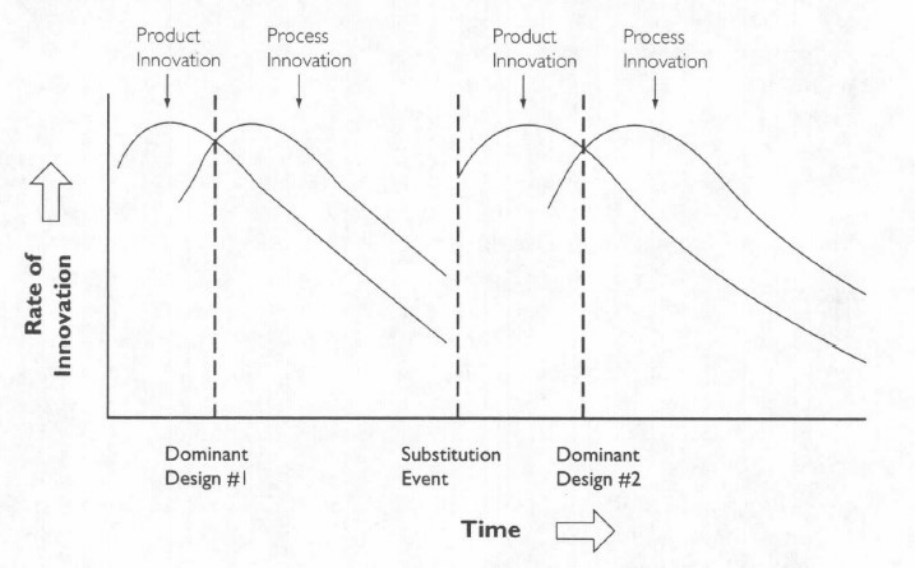

Figure 4: Technology Cycles and Disruptive Evolution

Source: Michael L. Tushman and Charles A. O'Reilly III, "Ambidextrous Organizations: Managing Evolutionary and Revolutionary Change" (*California Management Review*, Summer 1996, Vol. 38, No. 4): 16.

During this cycle, the best company was not producing the best personal computer, but the best-valued personal computer. At this point, the name of the game is efficiency (therefore in the complicated-simple domains) and small improvements to maintain the competitive edge. Steve Jobs was not the man for the job anymore and was replaced by John Sculley. John Sculley brought to Apple structure and processes that would enable better efficiency. However, in a volatile market, Apple soon failed to adjust and profitability slowly disappeared. Jobs came back in 1997 for another period of exploration and the creation of the iPod and iPhone, winning the race to produce a dominant design again. Apple exemplifies the success of developing two dominant designs. It survived and even thrived during multiple substitution events to become one of the most capitalized firm in the World. However, the consequences of not understanding the shift in the environment and acting accordingly can be dire. For example, both Kodak (photography) and Smith-Corona (typewriters) failed because of

the substitution event of digitization. Is DND/CAF facing a success trap? As a public organization, DND/CAF could not file for bankruptcy. Therefore, the catastrophic event of falling into the success trap has a different outline than for a business. However, there is a definite inertia in the capability development enterprise that was identified by multiple actors within and outside of the organization. In a contested environment, the national consequences could be much more serious in terms of loss of technological superiority that can lead to the loss of national power and even the loss of soldiers' life.

Charles O'Reilly and Michael Tushman studied the success trap phenomenon and concluded that the success trap creates structural and cultural inertia in an organization. This inertia or stability enables success in a stable market. Structural inertia is "a resistance to change rooted in the size, complexity, and interdependence in the organization's structures, systems, procedures, and processes."[37] Cultural inertia is more ingrained in the psyche of the organization. Cultural inertia is "the shared expectations about how things are to be done. These are sometimes seen in the informal norms, values, social networks and in myths, stories, and heroes that have evolved over time." These inertias are not immovable. There is an incremental evolution of the processes, procedures, culture, structures, etc. However, these successful organizations fail when the market shift. This is why, in the current technological ecosystem, start-ups are the best organizations to foster disruptive innovation, because they are more adaptable and explorative.

[37] Michael L. Tushman and Charles A. O'Reilly III, "Ambidextrous Organizations: Managing Evolutionary and Revolutionary Change" (*California Management Review*, Summer 1996, Vol. 38, No. 4): 18.

For O'Reilly and Tushman, the problem to be solved is: How a successful large company can gain a competitive edge or adapt rapidly enough in a volatile environment? Their proposed answer is ambidexterity.

Ambidexterity is "the ability of an organization to both explore and exploit-to compete in mature technologies and markets where efficiency, control, and incremental improvement are prized and to also compete in new technologies and markets where flexibility, autonomy, and experimentation are needed."[38] From a capability development perspective, the idea of ambidexterity can be found in dynamic capabilities, i.e. the organization's "ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments"[39] O'Reilly and Tushman propose that a large and stable organization cannot become as a whole an exploring organization. There is a requirement for the creation of teams that have a specific culture and structure that explores innovation and enables solving complex problems. However, large organizations already have heavy processes and procedures, a vertical hierarchical structure, and specific norms and values. Where this disruptive/exploring team could be nested inside the organization? In a recent study on 35 initiatives, O'Reilly and Tushman discovered that organizations have a 90% success rate in developing breakthrough innovation based on a specific structure, the ambidextrous organization, compared to between 0 and 25% for other structures[40]. The ambidextrous organization integrates the existing organizational structure with the emerging structure at the senior leadership level but separates the enabling functions of the emerging structure from the existing structure

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[38] *Ibid*.
[39] David J. Teece, Gary Pisano, and Amy Shuen, "Dynamic Capabilities and Strategic Management" (*Strategic Management Journal*, Vol. 18, No. 7, 1997): 516.
[40] Michael L. Tushman and Charles A. O'Reilly III, "The Ambidextrous Organization" (*Harvard Business Review*, April 2004).

(see Figure 5). Those enabling functions are, for example, R&D, administrative services, procurement, etc. In DND/CAF, CANSOFCOM could be regarded as an emerging structure. It has its specific processes, structure, and culture. For instance, CANSOFCOM does force development, force generation, force employment, and force sustainment within the same structure with only a few functions outside of its own structure.

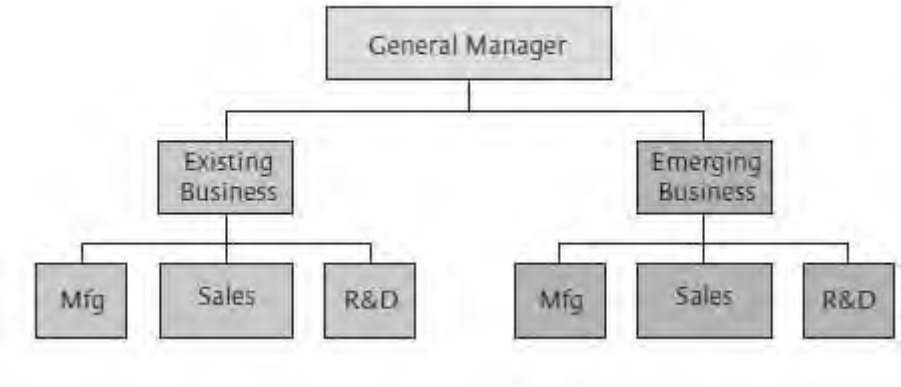


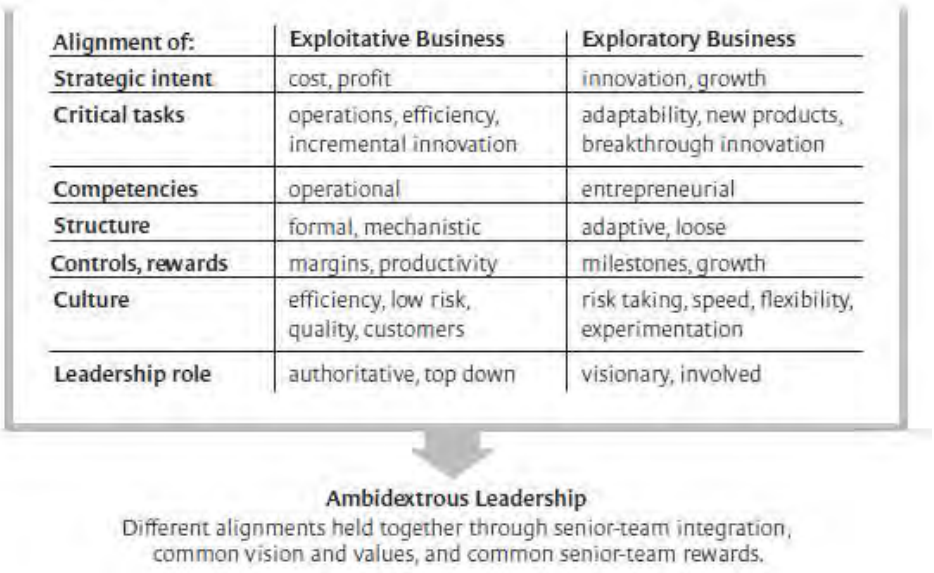
Figure 5: Ambidextrous Organizations

Source: Michael L. Tushman and Charles A. O'Reilly III, "The Ambidextrous Organization" (*Harvard Business Review*, April 2004): 6.

The one thing to retain is that this ambidextrous organization is not a functional structure, but an organization focused on having an impact, a dynamic capability. Therefore, the emerging structure needs to be fully functional to achieve a breakthrough but also on a separate risk management regime. It needs to be allowed to fail to a certain extent.

Figure 6 presents a comparative table between exploitative and explorative organizations. Exploitation and exploration are terms used in the Cynefin Dynamics to represent the movement between complex and complicated. Therefore, ambidexterity and the Cynefin framework identifies the same problem and proposes solutions that are

aligned with each other. In this current environment, an ambidextrous organization needs to have a part that exploits innovation by being efficient, productive, and incremental; and another part that is exploring, adaptable, and risk taking. Both Cynefin and ambidexterity represent the importance of the cross-boundary movement between complicated and complex in particular as being the biggest challenge for large organizations. Therefore, both the Cynefin framework and the ambidexterity concept stress the need to align within an organization the complex elements and the complicated elements and then, apply the relevant strategy execution frameworks in consequence. This is the reason why O'Reilly and Tushman emphasizes the importance of a structural touchpoint between the exploitative and exploratory parts of the organization. As the Cynefin dynamics show, there is a need to move between the two as complex problems will eventually require simple and applicable solutions.



Alignment of:	Exploitative Business	Exploratory Business
Strategic intent	cost, profit	innovation, growth
Critical tasks	operations, efficiency, incremental innovation	adaptability, new products, breakthrough innovation
Competencies	operational	entrepreneurial
Structure	formal, mechanistic	adaptive, loose
Controls, rewards	margins, productivity	milestones, growth
Culture	efficiency, low risk, quality, customers	risk taking, speed, flexibility, experimentation
Leadership role	authoritative, top down	visionary, involved

Figure 6: Comparative Table on the Scope of Ambidextrous Organizations

Source: Michael L. Tushman and Charles A. O'Reilly III, "The Ambidextrous Organization" (*Harvard Business Review*, April 2004): 8.

Conclusion

This chapter demonstrated that the contextual and multi-level alignment of strategy is essential to success. The Cynefin framework provides a powerful construct to understand complexity and how the different dynamics can apply to strategy execution frameworks at different levels. It was established that the most challenging dynamic to understand is between complex and complicated. The ambidextrous organization can provide the structure to enable the movement between complex and complicated. This movement, through the ambidextrous organization, will be primordial in the success of the next CAF strategy in a Pan-Domain environment.

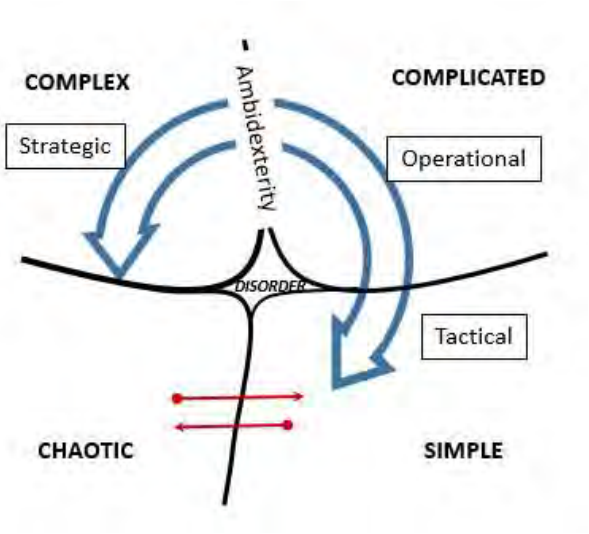


Figure 7: Multi-level Cynefin Dynamics for the strategic-operational-tactical

Source: Inspired by C.F. Kurtz and D.J. Snowden, "The new dynamics of strategy: Sense-making in a complex and complicated world" (*IBM Systems Journal*, Vol. 42, No. 2, 2003): 476.

Figure 7 is a high-level representation of the Cynefin dynamics applied to the strategic-operational-tactical pyramid as a military-related example. An ambidextrous CAF is capable, when the context changes, to re-evaluate simple problems at the edge of chaos and back to simplicity. However, in the current context, is there a specific need for

ambidexterity in DND/CAF capability development enterprise? Did the context change? "Canada and its allies face increasingly dangerous competition from malign and hostile rival powers."[41] This quote from the Pan-Domain Force Employment Concept (PFEC) illustrates the return of state competition as the main scenario for capability development. The rival powers are known and their capacity to innovate both technologically and conceptually in domains inside and outside of the traditional military domain is the main threat we are facing. Therefore, the PFEC is challenging the sole use of capability-based planning as the strategy formulation process in force development. With the failed NCW strategy, the upcoming new Pan-Domain strategy also demands a shift in reactivity to respond to new specific threats. This will put immense pressure on our current strategic execution processes unless a major change is operated. However, before looking into changes, we need to understand the patterns that lead the CAF to struggle on NCW and specifically on the development of the C4ISR spine.

In the next chapter, we will discuss two drivers for change: the necessity to incorporate threat-based planning in capability development and the complexity of developing SoS.

[41] Canada. Minister of National Defence. *Pan-Domain Force Employment Concept: Prevailing in an Uncertain World*. 2020: 11.

CHAPTER 2: DRIVERS FOR CHANGE

In the last chapter, the importance of the context was discussed as the primordial element for the successful execution of a strategy. What is the new context? The PFEC presents a World where the emergence of new threats and new technologies can disrupt the security of the country. Since we need to be aligned with the context, these new threats and new technologies are the drivers for change.

In this chapter, we will discuss the need to incorporate threat-based planning in the strategy formulation process and the development of a C4ISR SoS will be problematized as a complex endeavour requiring tailored strategic execution processes and an ambidextrous DND/CAF.

Capability-Based Planning vs Threat-Based Planning

For affordability reasons and because of the uncertainty of the Post-Cold War context, capability-based planning (CBP) has been selected as the method for strategy formulation. This method is based on "planning under uncertainty, to provide capabilities suitable for a wide range of modern-day challenges and circumstances while working within an economic framework that necessitates choice."[42] Without specific threats, CBP is building a general-purpose force structure.

In the PFEC, threat-based planning (TBP) is proposed to complement CBP because "we risk stagnating relative to our adversaries."[43] What does it mean? As our

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[42] Taliaferro and al. *Defense Governance and Management: Improving the Defense Management Capabilities of Foreign Defense Institutions: A Guide to Capability-Based Planning (CBP)*. (Alexandria, VA; Institute for Defense Analysis, February 2019): 1.
[43] Canada. Minister of National Defence. *Pan-Domain Force Employment Concept: Prevailing in an Uncertain World*. 2020: 27.

foes are known, specific threats can now be precisely identified, and disruptive technologies are being developed and fielded by our adversaries. The one recent example is hypersonic weapon systems, but that could only be the tip of the iceberg[44]. Josh Marcuse, executive director of the US Defense Innovation Board (DIB) from 2016 to 2020, said: "They will use AI, and they will fight at AI speed, and I don't want to show up with a dumb weapon on a smart battlefield."[45] This battlefield is not only in the traditional military domain but in pan-domain as well, where it could affect covertly Canadian citizens, businesses, and critical infrastructures. China is striving to achieve a technological advantage in AI with the risk to beat the allies in producing effective smart weapons. The impact of losing the technological advantage can be disastrous. For example, in the recent conflict in Nagorno-Karabakh, Azerbaijan procured drones only a few months before using them with the intent "to reshape military balances [in the south Caucasus] in its favor."[46] Their landslide victory is fully attributable to the integration of drone technologies in their tactics. In the current state of affairs, would the CAF fare better than Armenia? Therefore, it is evident that TBP has to be incorporated with CBP as a strategy formulation process.

CBP is iterative, albeit based on very long iterations called horizons (10 years). Still, CBP is a valuable process for a stable environment or, specifically, for stable segments of the environment, such as capacities that require to be life-cycled. For example, we know a replacement is needed for the Halifax class. However, as with

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[44] Philip E. Ross, "Russia, China, the U.S.: Who Will Win the Hypersonic Arms Race?" (IEEE Spectrum.17 Nov 2020, https://spectrum.ieee.org/aerospace/aviation/russia-china-the-us-who-will-win-the-hypersonic-arms-race).

[45] Joe Franco, "DIB Director Questions Collaboration, Deployment of Battlefield AI", last modified 26 June 2018, https://www.meritalk.com/articles/dib-director-questions-collaboration-deployment-of-battlefield-ai/.

[46] Burak Ege Bekdil, "Azerbaijan to buy armed drones from Turkey", last modified 25 June 2020, https://www.defensenews.com/unmanned/2020/06/25/azerbaijan-to-buy-armed-drones-from-turkey/.

specific breakthroughs such as deep machine learning in 2012 or specific threats, there is a requirement to explore disruptive technologies and tactics. Ambidexterity can provide the means to do both, explore disruptive technologies and tactics, and exploit by iterative development of current technologies and tactics.

An ambidextrous DND/CAF, an innovative organization, is an element of national power. Beyond the people and the platforms, which are the ostentatious element of military power, the outcomes of being innovative, of demonstrating ambidexterity are also an element of power. Showing to the World, our adversaries and our allies, our ability to innovate, integrate and be interoperable with timeliness and affordability is the best showcase of military power in the information age and a pan-domain environment. China is seeing it the same way: "The PLA's quest for innovation is an element of the Chinese national strategy to leverage science and technology in pursuit of great power status."[47] This quest for ambidexterity has to start with developing a capability that alluded us in the last 20 years, an effective, joint, integrated, and interoperable C4ISR SoS.

C4ISR or the complex challenge of SoS Integration

A C4ISR SoS is the crown jewel of military capability in the information age. As the central nervous system in the battlespace, C4ISR integrates sensors and weapons and provides a shared situational awareness with the purpose to achieve informational and decisional dominance. The goal of this section is to define a SoS and establish C4ISR as a SoS vs a unique system.

[47] Elsa B. Kania, “”AI Weapons” in China’s Military Innovation” (*Global China*, Center for Security and Emerging Technology, April 2020): 2.

System of Systems

If C4ISR is the central nervous system of the battlespace, armed forces require multiple interconnected SoS. The PFEC identified a list of capabilities that "did not progress at the same rate as others […] Medical support, C2, space, cyber, intelligence, surveillance and reconnaissance (ISR), counter unmanned aerial systems (counter-UAS), force projection, and large-scale sustainment […]"[48] What do those capabilities have in common? They are all part of a SoS. Along with C4ISR, air-defence, logistics, and medical support are all SoS by themselves. On the contrary, the CAF was successful at procuring and integrating other capabilities such as the Light Armored Vehicle (LAV-6), the C-17 Globemaster, and the CH-147F Chinook amongst others. They share the same characteristic of being platforms or individual systems. But what is the difference between a system and a SoS?

"A system is a collection of entities and their interrelationships gathered together to form a whole greater than the sum of parts"[49]. Theoretically, a SoS is also a system composed of parts. Why the LAV-6 should be considered a system and the Land Command Support System (LCSS) a SoS? Or, what part of the LAV-6 should be considered as part of a SoS?

Boardman and Sauser of the Stevens Institute of Technology, a leader in SoS research, proposed five elements that differentiate a SoS from a system[50]. First, the autonomy. The parts cede their autonomy to the system[51]. For example, the engine of the

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[48] Canada. Minister of National Defence. *Pan-Domain Force Employment Concept: Prevailing in an Uncertain World*. 2020: 27.
[49] John Boardman and Brian Sauser, "System of Systems – the meaning of *of*" (Proceedings of the 2006 IEEE/SMC International Conference on System of Systems Engineering, Los Angeles (CA), April 2006): 118.
[50] *Ibid*.
[51] *Ibid*.: 119.

LAV is not autonomous. It functions to enable the LAV itself to move. On the contrary, systems within a SoS are autonomous. For example, a battlespace management system (BMS) optimally requires the Position-Location Information (PLI) from the platforms in the battlespace, but it can also function as a standalone where PLI is entered manually by operators. Therefore, it is autonomous from the other systems in the C4ISR SoS. The BMS fulfills by itself one of the purposes of the SoS.

Second, parts are by design belonging to the system. Like a member of a family, the part can only belong to this specific system. However, systems inside of SoS negotiate their relationship with the rest of the SoS[52]. For example, legacy systems are often initially created with a unique purpose but require to be conditionalized to fit the greater purpose of the SoS. For instance, the data of the BMS needs to be modified to fit with the allies system. Therefore, the parts belong by design to a system, but a system often does not belong by design to the SoS. Interfaces are created to negotiate the exchange between the systems as is the case for the BMS with the NATO allies.

Third, connectivity. This is the fundamental difference between integration by design in a system and interoperability. In a system, sub-systems connections are managed separately with a maximum of 15% sub-systems to sub-systems interconnections[53]. This 15% is the maximum level of integration that can be managed. This would be unfathomable in a SoS. In fact, the purpose of a system within a SoS is to interconnect with other systems, to exchange data. Therefore, the SoS is more interoperable than integrated, i.e. the connectivity is dynamically managed vs deliberately managed because a SoS is operating in a more volatile and task-tailored environment[54].

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[52] *Ibid*.
[53] *Ibid*.: 119.
[54] *Ibid*.: 119-120.

For example, the powertrain of a LAV-6 has a limited inter-connectivity with the suspension sub-system. Where there is connectivity, it is mostly linear such as the weight of the powertrain affects the chassis sub-system. In a SoS, the inter-connectivity is network centric. For example, the BMS will aggregate data from multiple sources such as GPS, allies' BMS, interfaces systems, etc. and will push data to multiple systems. The inter-connectivity of a SoS is therefore closer to a neural network.

Fourth, diversity. In a system, "diversity encapsulated to create a known discrete module whose nature is to project simplicity into the next level of hierarchy".[55] Therefore, in a system, diversity is managed. For example, in the development and selection of the LAV-6 as the infantry fighting vehicle, the diversity of functions that it could achieve is limited. The LAV-6 cannot breach and cannot float. It does other functions well, but not those. This is a well-known and discussed conundrum in the CAF. What functions should a system do? If the demand for a system is too great, complexity and cost become too high. However, for a SoS, this question is open-ended. A C4ISR SoS has an almost unlimited and undefined number of functions. Individual systems within the SoS have specific functions, but the holistic SoS has an increased diversity of functions to perform, evolving in time and technologies. For example, commanders will require their C4ISR SoS to be tailored to a specific C2 structure and approach depending on the mission and the operational environment. The C4ISR SoS would not function the same way in a peer-to-peer conflict vs a counter-insurgency operation.

Fifth, emergence. This element is strongly tied to ambidexterity. By design, a system is made to rule out emergent behaviors. It is made to act exactly the way it was designed otherwise, it would be a flaw. SoS needs by design to integrate emergent

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[55] *Ibid*.: 121.

capabilities, capable of emergent behaviors. Therefore, a SoS goes from a stable state to a disruptive state willingly and out of necessity making it a fundamentally different problem set than a unique system. Otherwise, if it does not move to a disruptive state deliberately, if the incorporation of emergent behaviors are not managed, then the emergent behavior becomes an emergency, i.e. the SoS crashes. This signifies that within the SoS environment, both legacy and emergent systems will co-exist and interoperate[56].

The example of the LAV-6 and the C4ISR SoS does not do justice to the difference between systems and SoS. The LAV-6 is composed of multiple systems such as radios and sensors that are part of the C4ISR SoS. However, the Boardman and Sauser framework is useful to draw a line between unique systems and SoS. Work has to be done in the CAF to delineate between the two. Most importantly, the five elements of the Boardman-Sauser Framework demonstrate the complexity of SoS. SoS are complex because human cognition cannot know and understand all the inter-relations within them. They are not closed systems but open systems where a large community is stakeholders and in which any changes can create unforeseeable second and third orders of effects. Therefore, they should be treated as a complex problem requiring a strategy execution process capable of handling complexity. "The uncertain and unknowable environment in which the SoS must operate presents a mystery of endless proportions, the only proper response to which is to have increasing variety, of a continually emerging nature, to deal with the unforeseeable reality that eventually becomes clear and present danger."[57]

[56] *Ibid*.: 120-121.
[57] *Ibid*. : 122.

C4ISR

As early as 2000, Alberts and al. of the C4ISR Cooperative Research Program (CCRP) in US DoD identified NCW as the main military strategy for the information age[58]. As the main feature of NCW, Alberts and al. identified the development of an infostructure as the "entry fee" for NCW. This infostructure is the C4ISR SoS. C4ISR predates the idea of NCW. In 1996, Manthrope described what would be a Joint C4ISR system[59], the central nervous system of the information age military organization in the battlespace.

A C4ISR SoS could be represented by multiple sense-making models, dividing it into functions, requirements, assets, etc. Since the purpose of a C4ISR SoS is to gain information-dominance, the flow of information in the battlespace is the best way to understand the different parts of C4ISR. There is a natural information divide in the battlespace simply tied to the robustness of the infostructure in place. Figure 7 illustrates the different domains of the LCSS, the Canadian Army (CA) C4ISR SoS.

In simple words, mobile platforms (rolling or flying) can store, process, and transfer a limited amount of data using ad-hoc networks and smaller processing units inside the platform. On the contrary, transportable facilities are provided with more robust networks and capable of holding small data centers, which enable the storage, processing, and transfer of a larger amount of data, therefore a richer data environment. Permanent facilities are interconnected using enterprise infrastructure, therefore in a data-rich environment. At the other end of the spectrum, soldiers can carry a limited amount of

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[58] David S. Alberts, John J. Gartstka, and Frederick P. Stein, *Network Centric Warfare: Developing and Leveraging Information Superiority* (C4ISR Cooperative Research Program, 2nd Ed., 1999).
[59] William H.J. Manthrope, Jr., "The Emerging Joint System of Systems: A Systems Engineering Challenge and Opportunity for APL" (*John Hopkins APL Technical Digest*, Vol. 17, No. 3, 1996).

equipment, therefore having the smallest amount of data available. This natural information divide is also paralleled with the human cognition. The cognitive capacity of an individual soldier or a crew inside a platform operating in the battlespace is smaller than the collective cognitive capability of staff in facilities. Therefore, a C4ISR SoS is composed of four domains: permanent facilities, temporary facilities, mobile, and soldier. The four domains are traversed by and composed of multiple systems that can be categorized into three fleets of assets: information technologies, communication technologies, and sensors. Each of those assets has hardware and software embedded and interconnecting them within the SoS.

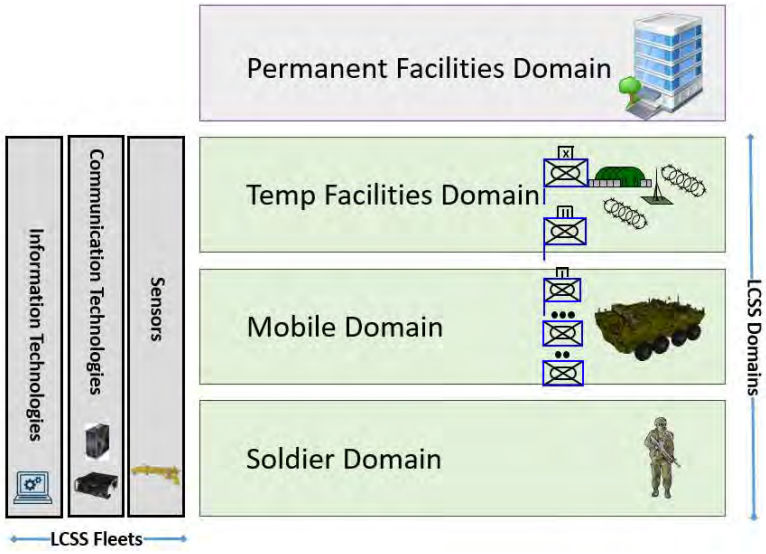

Figure 8 – LCSS Domains and Fleets

Source: Inspired by LCol Ian Graham's LCSS Domains Model

Also, as emphasized earlier and in the literature on NCW, C4ISR lacks by itself the human-system integration aspect necessary to successfully execute the NCW strategy. The human-system integration is the key sense-making function of NCW. A perfectly connected environment does not accelerate Boyd's OODA loop without human intelligence. The C4ISR SoS is mainly the mean to connect the different parts of the network by the transfer, processing, and storage of a vast amount of data, but human-

system integration is the key to enable this data to become information and eventually knowledge of the operating environment. Therefore, the C4ISR SoS has to integrate the human-system relationship. Any discussion on the execution of the NCW strategy has to view system-system integration and human-system integration as the same problem space by putting the human operator at the center of the solution.

The human-system integration adds a layer of complexity as the C4ISR SoS, like other types of SoS, needs more than the connection of 1s and 0s. Humans in the C4ISR SoS need to develop, configure, operate, manage, and use the different systems. In other words, a complex SoS evolving in a complex and volatile technological and operational environment needs to become simple enough that human cognition can do all of the above. This has a direct incidence on the multi-level alignment of the strategy execution process.

The PFEC and the VCDS letter to the capability development community state our difficulty to successfully develop SoS. The fact that 20 years after the elaboration of the NCW strategy, the creation of a C4ISR spine is still a priority illustrates this difficulty. Why are we having such difficulty to develop and integrate SoS? Simply, we fail to acknowledge that SoS are complex. They evolve in a technological complex environment and need to be tailored for a complex security environment. This is true for C4ISR, but it is also true for other SoS. If the CAF wants to be successful in the pan-domain environment, we will need to change the way we approach SoS integration, interoperability, and institutionalization. Are we close to a catastrophic failure? It is hard to tell. However, considering that if an organization fails at being ambidextrous, at crossing from complicated to complex deliberately, the risk that by inertia it crosses to chaos is increased.

Conclusion

This chapter presented the drivers for change. The request made in the PFEC to add TBP and the sheer complexity of the C4ISR SoS is a clear sign of a contextual shift driven by technologies and the security environment. Therefore, it is required that DND/CAF revise its strategy execution processes to match the level of complexity. Decisions in a complex domain cannot be made the same way they use to; the organization cannot be controlled by the same constraints. We need to understand the current paradigm. Is it feasible to re-align it with this contextual shift? How do we manage the complexity of SoS integration presently?

In the next chapter, we will demonstrate that the current capability development paradigm in DND/CAF is not tailored to ambidexterity. We will highlight the main characteristics of the current frameworks and how they hinder the development of SoS. This will enable us to draw a parallel between the framework model based on Cynefin and the current paradigm in DND/CAF.

CHAPTER 3: CURRENT PARADIGM

As early as the 1980s, it became clear that the rapid evolution of technologies required a process to develop new products. Scientists from management and engineering started to codify the best practices from the most successful companies. The Stage-Gate System introduced by Robert G. Cooper in 1990 encompasses those practices into a framework. The Stage-Gate System is based on normally five phases separated by "go/kill" gates (Figure 8). Senior managers act as the gatekeepers. "This gatekeeping group is typically multidisciplinary and multifunctional, and its members are senior enough to have the authority to approve the resources needed by the project."[60]

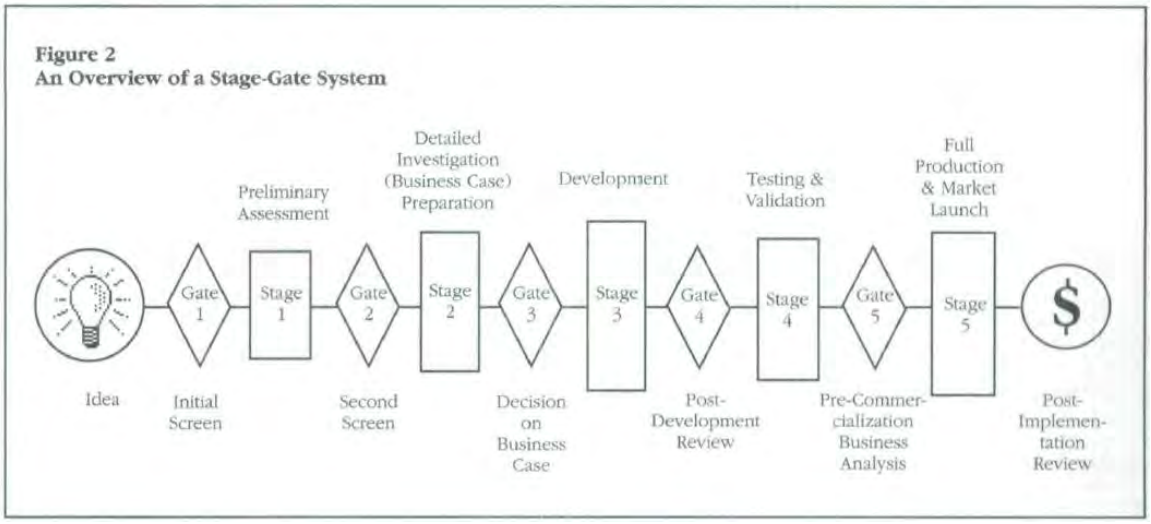

Figure 9: Overview of the Stage-Gate System

Source: Cooper, Robert G. "Stage-Gate Systems: A New Tool for Managing New Products." (*Business Horizons* 33, no. 3, May 1990): 46.

[60] Robert G. Cooper, "Stage-Gate Systems: A New Tool for Managing New Products." (*Business Horizons* 33, no. 3 May 1990): 46.

The Stage-Gate system has the advantage that it focuses on the quality and efficiency of the execution. The gatekeepers would ensure both, by the scrutiny of the projects, killing any projects that do not fit within the strategic context and reallocating resources toward better-aligned initiatives. Thus, it is a risk-reduction method ensuring that projects stay on track and relevant.

DND/CAF opted for this product development process as the basis for the development of capabilities. The DND Project Framework has the same objective as any Stage-Gate system, i.e. "projects will be approved in manageable phases that limit the Government's exposure to risk and maximize the Government's flexibility to choose between next steps."[61] Therefore, the DND Project Framework is a Stage-Gate system composed of five phases and four gates (Figure 9). The Project Approval Directive (PAD) describes in detail how this process is implemented within the DND.

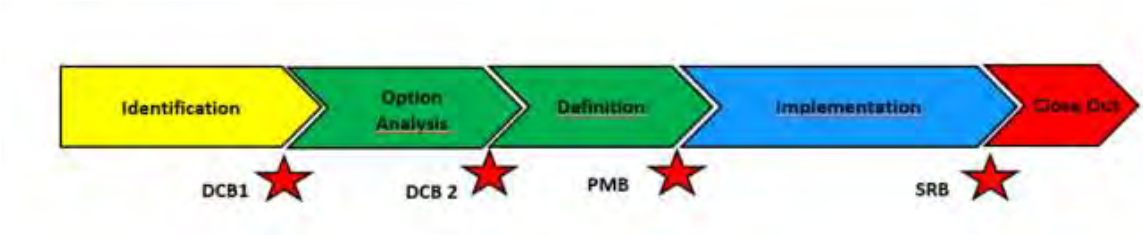

Figure 10: Simplified Version of the Standard Project Process

Source: Canada. Minister of National Defence. *Project Approval Directive 2015*. (11 March 2015): 3.

However, Stage-Gate was never a project management method but "a high-level model to guide the product development process." as argued by Cooper, its inventor.[62] This means that Cooper's Stage-Gate system is aimed at bridging the portfolio and the

[61] Canada. Minister of National Defence. *Project Approval Directive 2015*. (11 March 2015): 1.
[62] Robert G. Cooper and Anita Friis Sommer, "New-Product Portfolio Management with Agile" (Innovations Research Interchange, January-February 2020): 31.

project level. Therefore, in the study of the current paradigm, one has to expand on the strategic execution processes for every level. In the case of DND, we identify four different levels: the portfolio, program, project, and functional levels. There is a strong dependency between the processes chosen to execute the senior leadership strategies at each level and the structure of the organization including the authorities, responsibilities, and accountabilities embedded within that structure. Finally, as specified in the DND Project Framework, the management of risks in the organization is also affected by these important choices.

In this chapter, we will present the dynamics between DND/CAF four levels of capability development with the purpose of identifying the main characteristics of these dynamics. Our analysis identified three characteristics. First, the pre-development and strategic alignment. Second, the scaling of projects based on a risk assessment. Last, the complexity of integration. These three characteristics will underline the use of mechanistic processes to solve a complex issue, which is the primordial reason for failing to execute strategies in the complex domain.

Portfolio, Programs, Projects, and Functions

The strategic execution process of innovation within an organization is coined by different terms depending on the background of the authors. Mostly, system engineers will use the term new product development (NPD) while in the military, we use capability development (capdev). There is a semantic difference. Capabilities are known to be the aggregation of people, processes, and technology. Taliaferro and al. define capability as "the wherewithal to complete a task or produce an effect within a set of

specified performance standards and environmental conditions."[63] In fact, capabilities are components of the SoS that enables the pursuit of a specific course of action. It includes the know-how of the soldiers to use the different technologies, the passage of information that enables decision, the technological assets to achieve the aim, etc. For example, an integrated air defence system (IADS) is composed of a technology to sense incoming aircrafts or munitions, a radar. It also requires a procedure for individual soldiers to report the detection of aircrafts. It has an information system and a supporting network that enables the transmission, processing, and storage of the data within a specific timeframe. It has procedures that enable the action of striking a target based on the commander's risk assessment. To support all of this, the technology and the tactics need to be trained in different schools. It needs supporting processes, such as fleet management, change management, etc. Therefore, capabilities are based on a holistic perspective.

Products are generally much simpler than capabilities. In business, products are mean to achieve benefits, whether it is an item or a service. However, they also require many supporting processes. Complex products such as aircrafts or space shuttles have similar characteristics and complexity to the military's definition of capabilities: there is an interdependency between people, process, and technologies. For example, NASA uses the term product but adds a specific emphasis on Human Systems Integration (HSI). For NASA, the term 'system' is put in relation to 'capability'. NASA defines system as "the combination of elements that function together to produce the capability required to meet a need. The elements include all hardware, software, and procedures needed for this

[63] Taliaferro and al. *Defense Governance and Management: Improving the Defense Management Capabilities of Foreign Defense Institutions: A Guide to Capability-Based Planning (CBP)*. (Alexandria, VA; Institute for Defense Analysis, February 2019): 6.

purpose."[64] Therefore, the same requirements to aggregate people, processes, and technologies are present in the discussion of product development.

Beyond the semantic differences, the main question is whether NPD theories apply to capdev. Both NASA and all Western militaries including DND/CAF are currently using NPD processes. The essential element that differentiates them is the scale or the number of systems inside the military programs. For example, currently, there are about 300 projects in the pipeline of the Defence Service Programme (DSP) and the Land Equipment Program (LEP) alone is 30 fleets of capabilities, each of them composed of multiple systems[65]. This essential aspect of the capdev enhances the importance of understanding the current paradigm from a multilevel perspective and identifying the strategic execution processes of each of those organizational levels, their interdependencies, and their impacts on the successes and failures in the integration of new technologies.

In their review of literature, Letens and al. have identified that the most prominent researchers on NPD focus their work on three organizational levels: the portfolio level, the project level, and the functional level[66]. In the Project Management (PM) practice, the levels are segmented in portfolio level, program level, and project level. In analyzing the current paradigm in DND/CAF, it is clear that all four levels can be identified. However, the portfolio and program levels are interdependent and some could argue that in DND/CAF, they are collapsed. Both program and portfolio levels are intertwined in

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[64] NASA, *NASA Systems Engineering Handbook SE Handbook* (Aeronautics Research Mission Directorate, Washington DC, December 2007): 13.
[65] Canada, "Evaluation of the Land Equipment Program" last modified June 2015. https://www.canada.ca/en/department-national-defence/corporate/reports-publications/audit-evaluation/evaluation-land-equipment-program.html#ftn6.
[66] Geert Letens, Jennifer A. Farris, and Eileen M. Van Aken, "A Multilevel Framework for Lean Product Development System Design" (*Engineering Management Journal*, Vol.23, No. 1, March 2011): 69-72.

executing the organization's strategy. As we will expand on later, there is a transfer of leadership between portfolio and program levels within the DND Stage-Gate System, as program managers are also responsible for most of the lifecycle decisions of CAF capabilities. So, how can we define, differentiate, and identify interdependencies between the four levels?

First, the portfolio level has the objective to "select and deploy a valuable portfolio of projects that guarantees the long-term success in a global environment"[67] and to "optimize the return for the organization of the portfolio investment in a way that balances risk and return effectively."[68] In that sense, "a portfolio is a collection of projects, programs, subsidiary portfolios, and operations managed as a group to achieve strategic objectives." [69] In other words, it is the level that decides which set of capabilities that an organization needs to be successful in the future environment. The main challenge at the portfolio level is to define a method to select and prioritize capabilities in a context of limited resources and a rapidly evolving environment. DND/CAF is using CBP as the method to select and prioritize capabilities. As discussed earlier, the Stage-Gate System is the strategic execution process at this level, and the portfolio level authority is the VCDS and the Defence Capabilities Board (DCB). However, the resource allocation of the portfolio is a higher process that goes beyond the authorities of the VCDS.

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[67] *Ibid*.: 77.
[68] Crispin Piney, "Integrated portfolio and program management", (Project Management Institute Conference Paper, 2007) https://www.pmi.org/learning/library/integrated-portfolio-program-management-7409.
[69] Project Management Institute, The Standard for Program Management (4th ed. Newton Square, PA : 2017) : 7.

Second, the program level "provides the mechanism for controlling the strategic, financial and operational risks of major endeavours."[70] Programs are often defined as a set of projects with similar objectives or effects. However, programs also need to be understood as the lifecycle management level. Therefore, a program manages projects and activities "in a coordinated way to obtain benefits and control not available from managing them individually."[71] In simple terms, projects are all about outputs and programs about outcomes. In DND/CAF, the term 'program' is used at different levels. Capdev is defined as a program because it is a set of activities that produce outcomes (i.e. capabilities). From a strict PM perspective, the Defence Service Programme (DSP) is the programme (with the Canadian orthography) encompassing the entire DND/CAF projects portfolio; therefore, it should be called a portfolio[72]. However, the VCDS/Chief of Progamme (C Prog) and the PMB manage the execution of the DSP. The DSP is further divided between the elements and other L1s such as the Land Equipment Program (LEP) that manages the lifecycle of the Canadian Army capabilities. "In that sense the DSP could be described as a Programme of programs […]"[73] There is not one specific strategic execution process for program management in DND/CAF. The Program Alignment Architecture (PAA) is a "common government-wide approach to the identification of programs and to the collection, management and reporting of financial

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[70] Crispin Piney, "Integrated portfolio and program management", (Project Management Institute Conference Paper, 2007) https://www.pmi.org/learning/library/integrated-portfolio-program-management-7409.

[71] Patrick Weaver, "Understanding programs and projects—oh there's a difference!" (Project Management Institute Conference Paper, 24 February 2010) https://www.pmi.org/learning/library/understanding-difference-programs-versus-projects-6896#:~:text=The%20definition%20of%20a%20program,available%20from%20managing%20them%20individually.

[72] To differentiate the DSP from the sub-programs, the british/French spelling "programme" is used for the DSP, but the American spelling "program" for the sub-programs. In fact, the DSP is the portfolio. Ref: Canada. Minister of National Defence. *Project Approval Directive 2015*. (11 March 2015): 134.

[73] *Ibid*.

and non-financial information relative to those programs."[74] We could place the PAA as a performance monitoring process. However, most programs as a cluster of projects, or sub-programs of the DSP are using the project management process. In DND/CAF capdev, project management is the main execution process both at the program and project level. The authority of this level is the VCDS/C Prog with the Programme Management Board (PMB) as the main decision body at this level. Each element has a capability program managed by ADM(Mat) and there are specific parts that are managed by other L1s such as infrastructure by ADM(IE), R&D by ADM(DRDC), and IT by ADM(IM).

Third, the project level, in contrast with the program level, is focused on specifics and mandated deliverables. Projects have a clear beginning and end. The portfolio and the program levels will identify and monitor respectively outputs from the project level. The methods and the processes are normally agreed upon between the three levels. In DND/CAF, the DND Project Framework is allowing multiple types of project delivery methods. The selection of the method to deliver outputs will be briefed and accepted at the portfolio level. These methods range from cyclical project management inspired by Agile, gated project management, which is adding gates to the current DND Stage-Gate system, and standard project management.

Finally, the fourth level is the functional level. At this level, personnel "are not fully dedicated to a single project, but instead work on several projects at the same time, building knowledge about the same function over years."[75] There are three elements of

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[74] Canada. "Program Alignment Architecture 2015-2016", last consulted 5 March 2021. https://www.csps-efpc.gc.ca/About_Us/currentreport/paa2015-16-eng.aspx.

[75] Geert Letens, Jennifer A. Farris, and Eileen M. Van Aken, "A Multilevel Framework for Lean Product Development System Design" (*Engineering Management Journal*, Vol.23, No. 1, March 2011): 71.

the functional level that can define what is functional. Functional units generally have all three elements. First, the element of knowledge is paramount to the functional level. Normally, a functional sub-organization is established to maintain a high level of proficiency in specific knowledge. In this case, senior management structures a functional unit with the intent that the function is performed to a high degree of competency. Therefore, the function should be complicated, requiring expertise to perform it.

Second, the functional level is participatory in the matrix structure of the organization. For example, a project will utilize resources from the functional level for a specific use such as a costing expert or an IT expert. Therefore, one of the elements for creating a function is the utilization rate. If a specific resource is not fully utilized (normally close to 85% of utilization rate), then it should be "pooled" into a specific organization. This functional unit can be incorporated at the program level or within a specific functional sub-organization such as an engineering department or an R&D department. In the PM practice, there is a difference made between a weak, a balanced, and a strong matrix. The latter is when the utilization of functional resources is clearly stated in the project charter, and the former is when functional resources are not mandated to the project, therefore, they need to be requested. DND/CAF is largely using the balanced matrix project structure with the functional level. This means that there is a dedicated project manager in a project management organization but the PM is required to conduct his/her project through multiple functional processes.

Third, the functional level develops the different components that need to be integrated at the other levels. Therefore, depending on the strategic execution processes of the other levels, a certain amount of functional expertise is required at every level.

Thus, the functional level crosses the three other levels to provide cross-functional expertise. The structure and the mechanism between the functional level and the other levels are the center of gravity to successfully develop and integrate new capabilities. For example, in an organization built on a functional structure, the project manager would ensure that his/her project will efficiently follow all the functional processes to deliver on time, on budget. Seldom, a project team does not require the assistance of the functional level. However, as will be discussed later, the selection of the strategic execution process at the other levels should determine the organization of the functional level. When does a capability development initiative require an integrated cross-functional team and to which extent should functions integrate?

As quickly discussed in this section, because of the scale of the DSP, DND/CAF uses different strategic execution processes at different levels. The current paradigm is based on Capability-based Planning, the Stage-Gate System, and the balanced matrix project management. The functional level is integrated within the PM practices such as project charters. Does the current paradigm conducive to a complex environment and complex SoS? To understand how this paradigm fits with complexity, we need to identify key characteristics of the current paradigm. The next sections will develop on the three characteristics of the current paradigm and will highlight its shortcomings in developing a SoS.

Pre-development and Strategic Alignment

The current paradigm has three main characteristics that potentially can frame ambidexterity. However, in DND/CAF, the current paradigm fails to take into account the complexity of the context in the development of SoS. The presentation of the three

characteristics will enable us to discover the primordial reason why this system fails. Those three characteristics are: (1) a strong emphasis on pre-developmental processes, strategic alignment, and incremental level of commitment, (2) a risk-dependent scalable system, and (3) the complexity of integration through PRICIE+G. As it will be discussed in this section, the implementation of Stage-Gate and the project management process in DND/CAF have all those characteristics. However, the DND/CAF model has clear flaws: The scale of the DSP beats the purpose of the Stage-Gate system; the risk-management regime factors the wrong elements and does not align the developmental methods with the context.

The main role of the Stage-Gate system is to discipline the process. There is a natural tendency to jump from idea to development too rapidly, missing a thorough analysis of the pertinence of the new capability in the strategic context. Therefore, when we say that the Stage-Gate system's role is to discipline the process, it is mainly to assure that the first gates are not skim over without the proper assessment before a substantial investment is made into the development of a new solution. Companies that are successfully developing new capabilities are spending about twice the days and the money in doing their "homework", i.e. validating the concept, providing quality analysis on market assessment and the business case, trialing the capability, etc[76]. By implementing discipline and focusing on the quality of the process execution, the Stage-Gate system helps to reduce the risk of misalignment with the strategic environment and commits incrementally the resources based on logical assessments early in the development of a new capability. Therefore, those two aspects, strategic alignment and

[76] Robert G. Cooper, "Stage-Gate Systems: A New Tool for Managing New Products." (*Business Horizons* 33, no. 3 May 1990): 47.

incremental levels of commitment, reduce the risk of resourcing a false positive capability, a capability that does not meet the future needs of the organization.

However, each gate of the Stage-Gate system represents a potential source of delay, which would increase both the lead-time to launch and the overall cost of the project. Gatekeepers need to strike a balance between risk reduction by ensuring that the quality thresholds are met, and risk-taking by accepting a certain number of hypothesis. The more the risk management leans toward a cautious commitment to new projects, the more the threshold to pass each gate rises, higher is the cost of delaying. In simple terms, the threshold to pass a gate rises when there is a requirement for over-documentation and over-assessment of the different analysis requested to pass each gate. Cooper identifies overkill bureaucracy as one common mistake when implementing the Stage-Gate system. His main recommendation is the use of a scalable Stage-Gate system (Figure 10). The first gate is used to orient projects towards one of the three Stage-Gate processes based

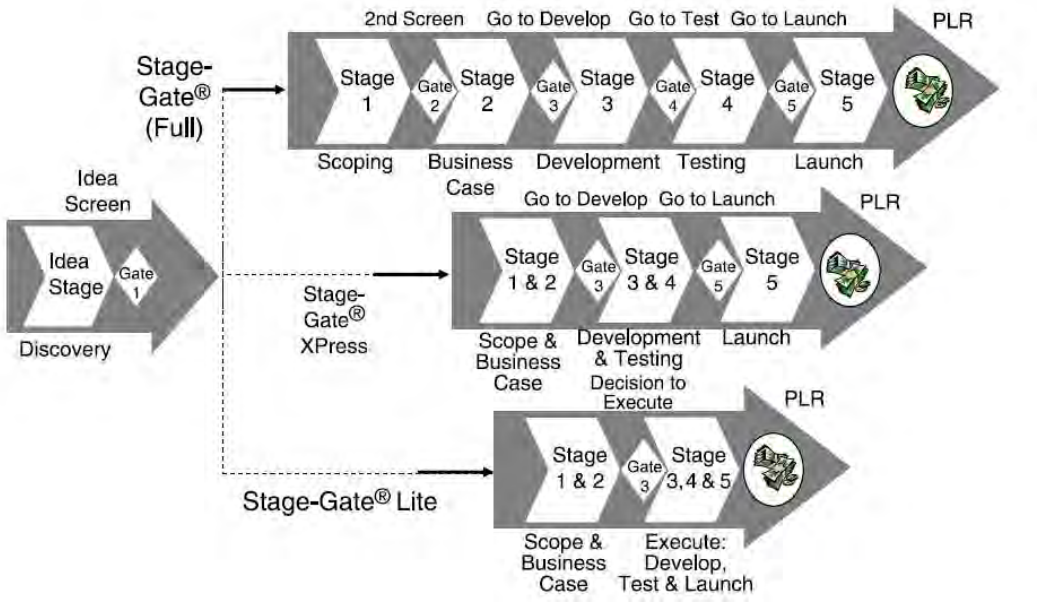

Figure 11: Next Generation Stage-Gate

Source: Robert G. Cooper, "Perspective: The Stage-Gate Idea-to-Launch Process –Update, What's New, and NexGen Systems" (*The Journal of Product Innovation Management*, 25, 2008): 223.

on risk assessment. “The higher the risk, the more one adheres to the full five-stage process […]”[77]

DND applies a version of Cooper’s Stage-Gate system. Tailoring the Stage-Gate system to the organization is recommended. Every organization needs to modify the phases and the gates for their own needs. In DND, the Stage-Gate system plays its role by efficiently disciplining the process and put an enhanced focus on the pre-development phases. Since the mid-90s, DND/CAF is using CBP as the concept validation process to de-risks capability duplication and balances needs and economics. The CBP process helps to validate the concept for a new capability during the first two phases of the process, identification and option-analysis. It is aimed at eliciting and situating requirements for the replacement of an existing capability or the development of a new capability in the context of the future capability posture of the CAF. Experts in the field of defense studies and senior military management develop and vet scenarios of future operational environments. Each capability has to be put into the perspective of the CBP. Therefore, the CBP ensures that projects pass through the two first gates with strategic alignment. In that sense, DND’s Project Approval system is consistent with the role of the Stage-Gate system to make sure that “homeworks” are done.

The rule-of-thumb in DND is that phases are two years each. However, some projects are going through those gates well within the two years mark, some even within one year, and others are many years over the mark. In general terms, projects that meet the threshold of each gate rapidly are strategically aligned. Strategic guidance such as *Strong, Secure, Engaged* habilitates the alignment of projects by listing the future

[77] Robert G. Cooper, “Perspective: The Stage-Gate Idea-to-Launch Process –Update, What’s New, and NexGen Systems” (*The Journal of Product Innovation Management*, 25, 2008): 223.

capabilities required by the CAF. Therefore, for the DND gatekeepers, the main risk is the strategic misalignment of a project. Project sponsors from the different Level 1 organizations (L1s) such as the Army, Navy, and Air Force have robust processes to ensure ideas are strategically aligned before submission to the first gate. For example, in the Army, ideas are analyzed at the Army Capability Development Board (ACDB) where CBP alignment is verified before the pursuance of any idea.

However, white papers tend to not age well because the strategic context is always evolving as we can see with the current pandemic[78]. Most of the time, the resource allocation part of the white paper is the first change to the status quo, but also the needs change with the operational environment (the threats and the technologies) and the lessons learned in operations. Therefore, there is always a requirement to re-assess the strategic alignment of new projects. The gatekeepers at the two first gates, the Defence Capabilities Board (DCB), need to risk manage judicially the balance between speed and prudence to avoid false positives and lack of timeliness. This underlines the dependency between a well-implemented Stage-Gate system and portfolio management. The portfolio managers ensure that the CAF has the capabilities that it requires; the Stage-Gate system is the capability development process that bridges the portfolio and the projects.

As stated earlier, CBP and the Stage-Gate system enable DND/CAF to discipline the process, ensuring strategic alignment and incremental level of commitment. However, there is also a requirement for TBP or a faster feedback loop into the system based on new threats and new technologies. Is the current CBP/Stage-Gate paradigm conducive to TBP? How the current paradigm enables disruptive innovation? The answer relies on the

[78] Eugene Lang, "The shelf life of defence White Papers" (*Policy Options*, 23 June 2017) https://policyoptions.irpp.org/magazines/june-2017/shelf-life-defence-white-papers/.

method the current paradigm uses to scale the process depending on risks. It is assessed that the way risks are managed in this current paradigm is not conducive to ambidexterity.

Gatekeeping and Risk Management

DND Senior Management is accountable to the Government of Canada in the delivery of the Defence Service Programme (DSP). However, as stated earlier, the DSP is a very large program. Was the Stage-Gate system designed for such a large program? It would be unfathomable for the gatekeepers to understand all 300 projects. Therefore, DND decided to split the gatekeepers' functions based on different levels and financial authorities. For instance, the gatekeepers are separated in three boards, DCB at the portfolio level, PMB at the program level, and the Senior Review Board (SRB) at the project level.

The DCB oversees the two first gates. It focuses mainly on strategic alignment. The PMB focuses on resource allocation and management. Since the costing starts early in the process, the PMB is seized of the project during the first two phases but recommends the expenditures at the second and third gates (going through Definition and Implementation). The SRB has the oversight function throughout the project. If some projects take many years to go through one phase of the Stage-Gate system, the project lead still has to brief the SRB annually. The SRB is thus responsible for the overall challenge function and performance oversight of the project. In that function, the SRB is also the gatekeeper for the fourth gate and the project closeout. The division of the three key functions, strategic alignment, resource allocation, and project performance oversight, is the chosen method to enable the management of such a large project

pipeline. This division is not part of the theoretical Stage-Gate system but a means for DND to manage the scale of the portfolio.

Added to this division is another division required for large projects, projects costed over 50M$. This division based on financial resources allocation is a risk management method providing an independent review for each gate. The Independent Review Panel Defence Acquisition (IRPDA) validates requirements in the two first phases of the project. The Investment and Resource Management Committee (IRMC) grants funding for Defence capital project over 50M$. It supplements the PMB in that regard. Figure 11 illustrates the financial approval levels. Finally, projects under 5M$ are called minor capital projects and they benefit from a scaled process. The average duration of a minor capital project is 2-3 years versus 10+ years for major capital project.

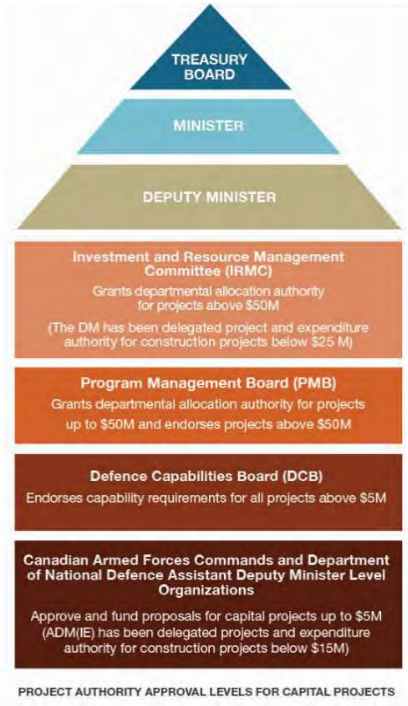

Figure 12: Project Authority Approval Levels for Capital Projects

Source: Canada, "Defence Investment Plan 2018, Part II: Transforming the way National Defence Works" (last modified 4 June 2019). https://www.canada.ca/en/department-national-defence/corporate/reports-publications/defence-investment-plan-2018/defence-works.html.

In a certain way, DND/CAF is also using a risk-dependent scalable Stage-Gate system. However, it is doubtful that the main criteria for risk should be solely the costing. Mainly, some projects could be very simple but procuring more of the same simple thing, and other projects could be complicated but procuring only one system. Also, an item can have a longer lifecycle than another. With accrual accounting, the amortized cost of the short-life item could be more expensive than the amortized cost of the longer life item, but the total cost of the latter would exceed the 50M$ threshold. This is often the case with high technology. They usually reach obsolescence faster than normal technologies and they are also often very expensive. However, if bought in small quantities, the costing of the project would be lower than the threshold for the full Stage-Gate system, but still representing more risks for the organization.

For this reason, the DND Project Approval Framework manages risks also using a complexity criterion. Following the complexity risk assessment, complex projects will use a different regime of approvals. “Projects that have an estimated lower complexity and risk will normally follow the routine Defence project management regime. However, larger, more complex or higher risk projects will be candidates for special management oversight.”[79] This “special management oversight” is assessed through the Project Complexity and Risk Assessment (PCRA) from the Treasury Board. Therefore, there are two main criteria for risk management that will affect the gates and the scale of the process, the costing, and the complexity.

The DND Project Approval Process is unique in the fact that there are up to five gatekeeping boards, each with specific decision-making responsibilities. The SRB keeps track of the project all along the process, but the other boards are only involved in part of

[79] Canada. Minister of National Defence. *Project Approval Directive 2015*. (11 March 2015): 144.

the process. As stated earlier, this is due to the size of the DSP, 300 concurrent projects. The Stage-Gate system was never meant to be managing 300 projects in parallel or to be split into five different decision bodies. That is because there is confusion in DND/CAF between Stage-Gate and portfolio management:

> Gates are an evaluation of individual projects in depth and one at a time. Gatekeepers meet to make go/kill and resource allocation decisions on an ongoing basis (in real time) and from the beginning to the end of project. By contrast, portfolio reviews are more holistic, looking at the entire set of projects, but obviously less in-depth per project than gates do. Portfolio reviews take place periodically: Twice to four times per year is the norm (Edgett, 2007). They deal with issues such as achieving the right mix and balance of projects in the portfolio, project prioritization, and whether the portfolio's is aligned with the business's strategy[80].

The DSP with 300 projects is not tailored for Stage-Gate, but a portfolio-level discussion. Gatekeepers are supposed to be experts and deep dive in projects to understand all the interdependencies and risk factors. As experts, they should readily understand the level of complexity of a project and be able to discriminate between complex, complicated, and simple projects. Already, in the PAD, complexity is a criterion for scaling the Stage-Gate system. This is positive. However, the level of complexity should not only inform the level of authorities but also what developmental process is required. Is project management an adequate method to develop a SoS? Evidently, project management is based on "good practice", is 'temporary and unique", and "incremental". All of those characteristics are in the ordered domain, thus not tailored for complexity.

[80] Robert G. Cooper, "Perspective: The Stage-Gate Idea-to-Launch Process –Update, What's New, and NexGen Systems" (*The Journal of Product Innovation Management*, 25, 2008): 228.

Second, the gatekeepers, as experts, should be able to consider the impacts of new threats or new technologies on their systems and modify the systems in consequence. This quick feedback loop is absent of the current paradigm. For example, the window to rapidly incorporate new technologies or new threats is at the beginning of the process. If a capability is not being life-cycled or is already in the last phases of the process, they are not inside the window. Project sponsors have to go through multiple boards to add the new requirements to a project or to start a new project. A turnaround time of 10 years is unacceptable when there is an urgency to "patch" the portfolio. This causes multiple *ad hoc* patches to capabilities as impacts are suddenly discovered outside of the window. For example, in the development of the LCSS, mobile data network requirements were substantially modified at least four times in the last 20 years. In 2003, the CA identified the need to connect its Intelligence, Surveillance, Target Acquisition, and Reconnaissance (ISTAR) assets and started the procurement of a new mobile data network as the backbone of the mobile domain of the C4ISR SoS. In 2012, it started the implementation of the network, 9 years after the requirement was identified. In between, the required level of interconnectivity was greatly increased with the addition of more assets and new expectations not estranged from the Afghan conflict. As of today, the "new" mobile domain network is still in implementation. Now, the capacity of the Royal Canadian Corps of Signals (RCCS) to sustain the network is in question. Also, requirements already evolved from 2012 and the "new" network is almost already obsolete. For instance, the allies are negotiating a new standardized waveform that will be able to hold quantum-resilient cryptography. In parallel, multiple projects failed to add their requirements for the mobile data network. Therefore, soldier-bourne radios are incompatible with vehicle-bourne radios, something that the project is already pressed to

recover. Also, a radar system was recently fielded without the incorporation of the requirements to both connect to field forces and airplanes through the mobile data network. Therefore, the data stops at the radar rendering the capability useless until it is fixed. Also, the RCCS struggles to support this new capability in terms of personnel and training. These examples illustrate the disorder created by using ordered processes in a complex domain. We need to understand where integration fails.

Is it fathomable that, at the level of seniority of the gatekeepers, and without any development started that they can effectively assess the level of integration, therefore of complexity, or understand the impact of a new threat and new technology? In the current paradigm, it is attempted by the use of multi-functional teams at all levels that assist the decision-making process of the gatekeepers.

The Complexity of Integration

The last sections presented risk management as the pivot between different scales of the process. We also discussed the two risk criteria of the DND Project Framework: cost and complexity. Currently, a higher level of risk triggers more oversight. However, it does not question the developmental method for complex projects. This is because there is confusion between portfolio management and the Stage-Gate system. The second shortcoming is the method used by DND/CAF to integrate complex capabilities in a rapidly evolving environment. In this section, we will discuss how the PRICIE+G concept is used to integrate, but the DND/CAF version of Stage-Gate hinders reactivity in a complex domain.

The Stage-Gate system allows the parallel processing of projects, which means that “activities are parallel rather than sequential. At each stage of the gateways system,

many activities take place concurrently and involve different functions of the firm."[81] The concurrency of activities is what permits the Stage-Gate system to gain efficiency while maintaining the quality of execution[82]. Project teams require the expertise of functional experts to prepare for the next gate and advance the concurrent activities. Gatekeepers, as described earlier, also need to be multifunctional and multidisciplinary teams to effectively assess the value of the project.

DND Project Framework meets this requirement. Project teams must prepare functional plans such as material acquisition, capital construction, environment, technology development, information management, and HR[83]. The DCB, the Programme Management Board (PMB), and the Senior Review Board (SRB) are all composed of multifunctional and multidisciplinary teams. For example, the Project Leader chair the SRB, which is co-chaired by the Project Sponsor representing the Level 1 organization sponsoring the project, the Project implementer typically from the Material Group, and a representative of the Chief Financial Officer (CFO). All functional Level 1 organizations are invited as observers. These observers could come from any party that has a vested interest in the project such as construction experts from ADM(IE) or scientists from ADM(DRDC). The DND Project Framework also places key functional milestones along the process. For example, costing is started in the first phase, Identification, refined in the second phase, Option Analysis, and finalized in the third phase, Definition. In this way, it forces the project team to start the costing assessment early in the process. In the DND Project Framework, the project charter describes the roles and responsibilities of each

[81] Robert G. Cooper, "Stage-Gate Systems: A New Tool for Managing New Products." (*Business Horizons* 33, no. 3 May 1990): 49.
[82] *Ibid*. : 50.
[83] Canada. Minister of National Defence. *Project Approval Directive 2015*. (11 March 2015): 135.

member of the project team including the functional experts. Through this charter, the governance of the project is tailored to the different types of projects. However, as discussed in chapter 2, integrating all those functional elements in a SoS is a complex endeavour. In this current paradigm, how can the gatekeepers, the program, and project managers integrate all of these elements into a SoS?

The integration of a capability is a complex topic. Integration is multi-dimensional, multi-faceted. Integration of a capability is required when this capability is part of a system. In that sense, the CAF is a system. In chapter 2, we defined a system as "the combination of elements that function together to produce the capability required to meet a need. The elements include all hardware, software, equipment, facilities, personnel, processes, and procedures needed for this purpose."[84] This definition is consistent with DND/CAF use of the PRICIE+G concept.

> **P**eople, **R**esearch & Development, **I**nfrastructure, **C**oncepts of operation and doctrine, **I**nformation Technology, and **E**quipment, Support and Sustainment (PRICIE) is a concept for holistic capability development that recognizes how even the most sophisticated and advanced technologies won't produce the desired results unless they are fully integrated into DND/CF.[85]

Generation was added to the PRICIE concept to encompass the training needs of the force. The PRICIE+G analysis is discussed all along the Project Approval Process. As the project approaches the implementation phase, the PRICIE+G analysis is refined to ascertain that the capability will be integrated within the wider CAF SoS. However, in a

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[84] NASA, *NASA Systems Engineering Handbook SE Handbook* (Aeronautics Research Mission Directorate, Washington DC, December 2007): 13.
[85] Canada. Minister of National Defence. *Project Approval Directive 2015*. (11 March 2015): 128.

letter to the capability development community, the VCDS demanded "more integration":

> We are using process to acquire 'a thing' and treating its inter-dependencies in some cases as an after-thought; to be stitched up later. […] We must truly begin integrating our systems-of-systems into a coherent CAF combat system that can see, recognize and exploit across boundaries. […] People, infrastructure, sustainment etc must be pulled to the left and connected earlier in our project work.[86]

The DND PAD, the processes in place, is factoring integration concerns to the left of the Stage-Gate system, therefore early in the process. Why is it not working?

As discussed earlier, the Stage-Gate system is effective as a transmission belt between the portfolio and the program/project level. Gatekeepers can discipline the integration process by making sure it has been considered, but the impact on the resource allocation (in this case, changes in the force structure) and on the strategic alignment are their main concerns. The program, project, and functional levels are responsible for the integration details within the SoS. The senior leaders that assume the role of gatekeepers cannot think of all the possible integration impacts. The gatekeepers cannot make sure that every bay doors on CAF buildings are large enough for the passage of a new vehicle. They cannot confirm that a new information system is compliant with the last STANAG. They cannot as well identify all the changes required in a school lesson plans. Even with the best SME around a table at any level, it would be unfathomable for them to draw all the required conclusions to integrate properly a new capability within the CAF wide SoS. For example, an Army project that needs to integrate would have to coordinate with the Defence Team Establishment Plan (DTEP) to modify the HR requirements (people),

[86] Canada. Vice Chief of the Defence Staff. *Open Letter to the Capability Development*. (Ottawa, ON, 29 October 2020): 2.

ADM(DRDC) through the Army Science and Technology Board (STB) for R&D, ADM(IE) to modify infrastructure, the Army Doctrine Center to make changes on the doctrine including the lower Standing Operating Procedures and TTPs, ADM(IM) and other directorates within ADM(Mat) to modify the IT infrastructures, ADM(Mat) for equipment and sustainment, and finally CADTC to modify training. Each of those considerations often requires a separate process. Each of those processes is resource-intensive. Individually, they are in the ordered domains but collectively, they augment the complexity of the whole capability development process. For example, during the training need analysis of the Canadian Forces Individual Training and Education System (CFITES), a requirement for additional days of training could be identified. These training days are not financed by the project since, during the costing process, this need was unknowable. A design choice, a new procedure, can be the cause of this addition of training days, therefore it is discovered only late in the implementation phase. The separate process to add training days and the resource allocation process to finance those training days are evolving separately from the fielding of the capability. Eventually, hundreds or thousands of those small failures to integrate create a totally disjointed SoS. The problem raised by the VCDS is therefore in the complexity realm. But, the PRICIE+G analysis woven into the Stage-Gate system as the main mechanism of integration is based on an ordered domain process, i.e. experts sitting around a table trying to understand the interdependencies between each of their functional areas.

For example, there are 300 projects and a countless number of systems each going through the PRICIE+G analysis to find interdependencies with multiple functional areas that each require a separate process. One solution that is proposed is to use enterprise architecture such as the DND Architectural Framework, an ordered domain solution.

Hypothetically, if DND/CAF would massively invest in enterprise architecture and try to map all the dependencies between systems, systems' requirements, and the PRICIE+G impacts of those systems, the architecture would be enormous, beyond human cognition, and irrelevant as changes in one system have unforeseeable impacts on other systems. When PRICIE+G analysis are made during the different stages, the SMEs do not have a mental architecture or a written architecture of all the interdependencies of the SoS. Therefore, the PRICIE+G is made by idiosyncrasy and constantly, integration requirements are found too late in the process or not found at all until the capability is fielded. Therefore, the problem space of SoS integration is complex but the proposed solution and the current paradigm are complicated, asking for the expertise of misinformed SMEs discussing of an environment that is in movement and for which the impacts are beyond human cognition.

However, in the current paradigm, the Stage-Gate system and project management deliver what they promise. Stage-Gate delivers on process discipline, strategic alignment, and risk management. It also enables to encapsulate different methods of development in its structure. Project management also delivers on "temporary and unique" projects. Both never promised, as execution processes, to develop SoS. We are using the wrong tools, because they were tools that successfully procured and integrated unique systems, such as platforms. Stage-Gate and project management still have their place in an ambidextrous DND/CAF, but with major changes, especially in the way Stage-Gate is being used.

Conclusion

Disorder "applies when it is unclear which of the four contexts [of the proposed Cynefin domain] is predominant." For a long time, the integration of capabilities within DND/CAF was a knowable endeavour. The whole capdev enterprise is focused on procuring a piece of equipment and then, sequentially, integrating it inside the institution, using PRICE+G. When the NCW strategy was selected, DND/CAF senior management never reconsidered the alignment between the strategy formulation and execution. 20 years later, the development of a C4ISR spine is still a priority and other SoS are also missing. In this chapter, we identified two reasons. First, the misuse of the Stage-Gate system. It was never designed for the gatekeepers to be experts on 300 projects. The resource allocation and selection of the 300 projects are portfolio-level decisions. The portfolio level evolves in the complex domain. It needs to be on a different decision-making regime. This new regime needs to enable TBP along with CBP. Second, integration is complex, not complicated. One must realize that project management and the Stage-Gate system are not tailored for integration. We need to use a framework to integrate our SoS in the complex domain. However, this framework is required to move SoS integration from complex to simple for troops to be able to use these systems.

In the next chapter, we will discuss what frameworks can enable TBP and SoS integration. These frameworks are proposed to be the strategy execution processes tailored for the new Pan-Domain environment.

CHAPTER 4: LEAN-AGILE FOR AN AMBIDEXTROUS CAF

In Chapter 3, we demonstrated that the current paradigm has two major issues. First, the defence portfolio is too large for the Stage-Gate system alone. Second, the integration of a SoS is a complex endeavour and cannot be managed by mechanistic processes. In this chapter, we will recommend an execution process that solves those issues by enabling the movement between complex and simple and vice-versa. As discussed in Chapter 1, the Cynefin dynamics provide guidance to this movement and are primordial in the implementation of the proper execution processes for an ambidextrous CAF. Figure 13 presents the proposed Cynefin dynamics applied to capability

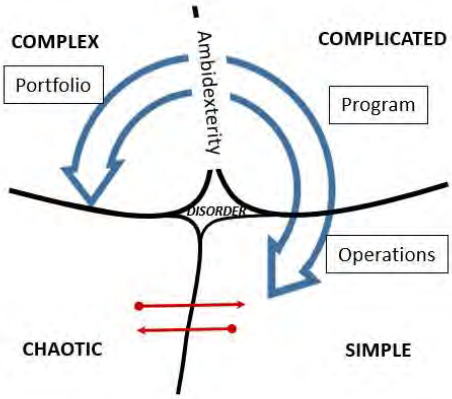

Figure 13: Multi-level Cynefin Dynamics for Capability Development

Source: Inspired from C.F. Kurtz and D.J. Snowden, "The new dynamics of strategy: Sense-making in a complex and complicated world" (*IBM Systems Journal*, Vol. 42, No. 2, 2003): 476.

development. We already established that the portfolio level is complex because of the requirement for TBP and the number of concurrent projects that are managed at this level. However, the current paradigm fails at bridging this complexity towards the complicated domain, where subject-matter experts can develop knowledge on their

specific segment of the portfolio. We also discussed that integration is done at the program level and therefore the program level should enable the operations of the different systems to be coherent and simple enough. Since SoS are complex to integrate, programs require a process that will bring this complexity to the knowable/known domain. In sum, the proposed execution process should have the characteristics of the Cynefin dynamics as shown in Fig. 13. Mainly, the complicated to simple dynamic is characterized by incremental improvements based on the information-decision flow. A certain level of information quality has to be reached to come to a decision based on inductive reasoning (probability). For the complex to complicated dynamic, the required level of information quality will never be reached. Therefore, decision-makers need to discern patterns and make decisions based on abductive reasoning (plausibility).

In this chapter, we will present Lean-Agile as the proposed solution. However, Lean-Agile is a vast framework and authors disagree on what is Lean-Agile. We will therefore propose to use the elements of Lean-Agile that fit the characteristics of the Cynefin dynamics. This chapter is divided into two parts, each part tackling one issue identified in Chapter 3. First, we will see how an ambidextrous CAF should be structured. As demonstrated by Tushman and O'Reilly, in their definition of the ambidextrous organization, fully functional sub-organizations are required to explore the specific environment of SoS. This structure equates to a central concept of Lean Product Development, the value-stream mapping. Second, we will present three characteristics of Lean-Agile that enable the integration of SoS: establishing a cadence based on the information-decision flow; a role-based division of labour between the leader, the architect, and the operator representative; and DevOps as a method to weave a

community of practices between the developers and the operators that enables to be agile in integrating SoS.

An Ambidextrous CAF for SoS

In Chapter 3, we identified that the current portfolio is too wide to enable the integration of the 300 projects in the pipeline. Also, the current paradigm is not conducive to complexity where change is the constant, not the exception. Each of the PRICIE+G letters represents a different functional unit or silo in the capability development process. Therefore, if a change is required at any level, the impact of this change needs to be taken into account in each silo. From a SoS perspective and in the current technological and security environment, this method is too cumbersome and creates massive lead times and dropped requirements. This explains why DND/CAF failed to develop a C4ISR spine: We did not align the processes required by the complexity of the development of a C4ISR SoS. In this section, we will see how an ambidextrous DND/CAF should be structured to fix this problem, i.e. to facilitate the dynamic between complexity and complicated.

As discussed in chapter 1, an ambidextrous organization separates functional teams tailored for exploration and complexity from the rest of the organization but linked at the senior management level to maintain strategic alignment. As demonstrated in chapter 2, since a C4ISR SoS is complex and needs to enable emergent innovation, it should be structured separately. This separate structure is not necessarily encompassing all of the letters of the PRICIE+G. For example, the first P is for people such as HR. HR policy writers are a niche capacity in DND/CAF and it would not be coherent to have dedicated policy writers in a separate C4ISR organization. It would not meet the

utilization rate criterion or help to streamline the capability development process. Therefore, we need to introduce one of the main Lean Product Development (LPD) principle: value-stream mapping (VSM)[87]. VSM is the analysis of the overall process to develop or manufacture a product from the very beginning to the client. The goal is to reduce waste. The concept of waste is primordial in Lean. It comes from the study in the 80s and 90s of the Toyota Production System. Researchers discovered that the Toyota Motor Company was more efficient than their North-American counterparts because it was reducing seven wastes: waiting, transport, unnecessary movement, inadequate processes, inventory, overproduction, and defects[88]. VSM is thus used to identify wastes in the manufacturing process. Just-in-Time logistics and Six Sigma come from the branch of Lean manufacturing. However, product development is fundamentally different from manufacturing[89]. In product and capability development, information is most valued, therefore wastes are intricately tied to the misuse or the loss of information. Thus, VSM in LPD is the analysis of the information-decision flow. This analysis of the value stream delineates the specific PRICIE+G functions within the separate structure to create the least wasteful information-decision flow.

For example, as discussed previously, the C4ISR SoS is heavily impacted by the breakthrough in 2012 in machine learning. However, this breakthrough is not a single event. It has many rippling effects and therefore, the C4ISR organization will need to iterate multiple plausibilities before finding the right patterns to counter and leverage the use of AI in the battlespace. To effectively react to these disruptive events, a separate

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[87] Lean Enterprise Institute, "A Brief History of Lean", accessed 5 April 2021, A Brief History of Lean.
[88] Ibid.
[89] Eduardo Gomes Salgado and Rob Dekkers, "Lean Product Development: Nothing New Under the Sun?" (International Journal of Management Reviews, Vol. 20, 2018): 909.

C4ISR organization requires a dedicated R&D unit to understand the technological impact of this breakthrough, gather information on the application made by foreign powers, friends and foes alike. It also requires a separate procurement cell to buy the services and equipment and a team to modify the concepts of operation, the doctrine, and the training. Finally, it needs to support the SoS while it is operated. All of this needs to be supported by a robust feedback loop as operators find new applications of AI and identify shortcomings of the current application. The next section will elaborate on the inner workings of this organization. However, with this example, we can see that VSM for LPD focuses on the information-decision flow. The structure and the authorities need to be tailored on the flow to reduce wastes in the development of new capabilities. An ambidextrous DND/CAF structured based on VSM would have three major impacts on the portfolio level.

First, it challenges the force development, force generation, force sustainment, and force employment construct (FD/FG/FS/FE). The separation of those four functions is wasteful because the information-decision flow runs through all of them for any given capability. For instance, the force generator produces the requirements. With those in hand, the force developer procures the equipment and integrates it. Once the equipment is fielded, the force sustainer supports the equipment for operations. In turn, the force generator trains the capability in field exercises and hands over the capabilities to the force employer to be used in operations. This will elicit new requirements that will feed the force developer, etc. This is an information-decision flow. In the current paradigm, this information-decision flow is wasteful because, in the development of a complex capability, the sequence of the flow is not like a waterfall where all the water falls into a basin before reaching a sufficient level where it falls in the other lower basin, etc. For

example, many projects have difficulty receiving requirements from the force generator. Requirements are normally crafted during working groups, in a few events at best. However, as the development goes forward or the environment changes, these requirements are not updated or detailed because it is too long and too complicated for the project team to go back to the upper basin where requirements are crafted. Also, most of the time, the requirements initially crafted in words that are not specific enough because of the limit of the language. Normally, requirements in a complex environment and with complex systems are iteratively crafted where developers present a partial solution to the operator, that confirms if it meets the requirements or not, it is made by interactions. Also, the operators do not necessarily have a long-term view of the environment. The flow requires a total alignment and feedback loops that will correct this alignment as the situation evolves and information is gathered. Therefore, there is a constant information-decision flow at multiple levels between force development and force generation. This is also true for force sustainment. For example, a maintainer can find flaws in a design that needs to be corrected by the developer or needs a workaround for the force generator and force employer.

The FD/FG/FS/FE structure is wasteful because it does not follow the information-decision flow. It forces management to measure the touchpoints between each of them and not the output of the complete flow. Therefore, the question is what is the output of the complete flow? The output is capabilities: technologies, tactics, and trained personnel. The selection of capabilities is a portfolio decision and the portfolio level should mainly measure the output, not each of the touchpoints between FD, FG, and FS. Therefore, it is the FE that should measure the output, not the FG.

This is the second impact of VSM on the portfolio. The FE is the one receiving the output, i.e. the "client". The value in VSM is the feedback from the clients, its satisfaction that the capability meets the ends. For the CAF, the "client" is the Government of Canada. The government mandates the CDS to conduct an operation. Most of the time, the CDS instructs the Canadian Joint Operational Command (CJOC) to execute the operation. These are the FE and the "clients". In the current paradigm, the feedback loop to the portfolio level is mainly the FD and FG. For example, the FD (project lead) and FG (project sponsor) are the ones that present the full operational capability certification to the SRB, which certifies that the project met the requirements[90]. This will lead to the project close-out being approved by the PMB. This is an apparent conflict of interest as the FG and FD are responsible for the development of the capability. Only the FE should be allowed to certify a capability and report back to the portfolio level. That said, the FE should not be involved in FD. Currently, CJOC supports the development of many joint capabilities but perhaps it should be done in separate organizations, freeing CJOC to concentrate on its core mandate.

The third impact is key to reduce the complexity of the DSP. Instead of monitoring 300 projects concurrently using the Stage-Gate system, the portfolio level should manage programs. In this case, the programs are the major SoS of DND/CAF. The elements (land, sea, air, special forces, cyber) should be augmented by joint capabilities such as logistics and C4ISR. These are the threads between the elements, the central integrating SoS of the CAF. Figure 13 illustrates the proposed CAF mission threads, the main SoS of the CAF. This map of CAF mission threads and their associated services is

[90] Canada. *Project Approval Directive 2015* (Director Defence Programme Coordination 6, 11 March 2015): 31.

sourced from the US DoD mission threads analysis. A mission thread "is a description of the end-to-end set of activities and data that are required to successfully execute an element of an operation mission."[91] Mission threads are therefore similar to VSM as an analytical method to describe an end-to-end process. This is one view of the segmentation of SoS in the CAF, but, as discussed in chapter 2, the CAF needs to discern what is a SoS from unique systems based on the Boardman-Sauser criteria.

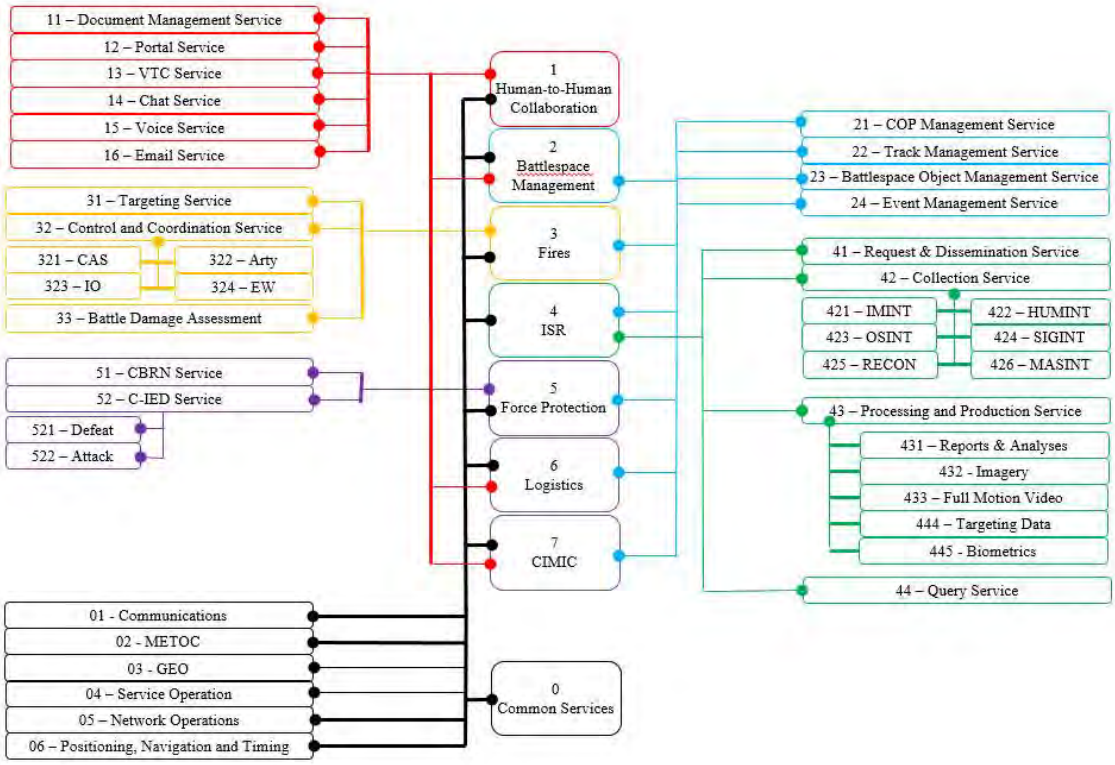

Figure 14: CAF mission threads and their associated services

Source: Inspired by United States Coalition Interoperability Assurance & Validation, "Mission Threads and Their Associated Services for Coalition Operations" (US CIAV Program Support Office, version 0.91, 23 April 2015): 3.

[91] United States Coalition Interoperability Assurance & Validation, "Mission Threads andTheir Associated Services for Coalition Operations" (US CIAV Program Support Office,version 0.91, 23 April 2015): 4.

The point here is that the portfolio should look into programs based on SoS not each individual project and thus the project portfolio needs to be divided in a palatable way where experts can use the Stage-Gate system to deep dive into the projects' specifics. In turn, the individual projects should be reviewed by experts in the specific SoS at the program level. These experts at the program level should use the Stage-Gate system to ensure the integration details are being completed. Also, they could apply a better risk management regime since, by their expertise, the information would be better comprehended, therefore risk can be taken in full conscience of the potential impacts. However, currently, projects go to the gatekeepers at the portfolio level because the gatekeepers have the spending authority. Could this authority be delegated to the program level? Not with the current governmental rules. It would not change the resource allocation process dictated by the Treasury Board. However, the portfolio level would interact with experts in a specific SoS that can put in perspective the capability and have the end-to-end responsibility and accountability to deliver on a specific program. They will also have the resources to match this responsibility, i.e. a separate sub-organization. This organization will be focused on integrating SoS.

In the next section, we will discuss how the C4ISR SoS sub-organization should be organized. The key conclusion that needs to be carried over to this next section is the importance of the information-decision flow in structuring an organization in a complex environment. A sub-organization responsible for a SoS integration needs to be reactive to the information-decision flow, as information is contextual, disruption in the environment should lead to changes in the flow within the sub-organization enabling a rapid movement from complex to simple and back when required.

Integrating a SoS

In the last section, we presented VSM in LPD. VSM in LPD is concerned with reducing wastes in the information-decision flow. To become an ambidextrous CAF, sub-organizations that follow the information-decision flow need to be created to successfully integrate complex SoS. In this section, we will elaborate on the three main characteristics of these sub-organizations. These characteristics add elements of the Agile framework in Lean-Agile. First, a role-based division of labour. These roles are similar at all levels, from portfolio to individual systems creating a team of teams and specific expertise in leading development teams, architecture, and requirements engineering. Second, the establishment of a cadence based on the information-decision flow. Finally, the use of DevOps to foster a community of practice between developers and operators bridging the information-decision flow between two different communities and enabling the reactive passage of complicated systems to simple procedures. These three characteristics enable the team of teams to go through the Cynefin dynamics that are essential to succeed in executing a complex strategy in a complex environment.

In February 2001, 17 experts in the field of software development created one of the most revolutionary heuristics in the world of development, the four values of the Agile Manifesto.

Individual and interactions over processes and tools
Working software over comprehensive documentation
Customer collaboration over contract negotiation
Responding to change over following a plan[92]

[92] "Manifesto for Agile Software Development". Last consulted on 5 April 2021. https://agilemanifesto.org/.

What are those heuristics if not a means to move from complexity to simple? As David Snowden, the author of Cynefin, mentioned, heuristics or rules of thumb are the best way to manage in a complex domain because they communicate a simplified rule of a pattern[93]. To bring back the example of macroeconomics: Raise the interest rate and the inflation will stabilize. This is also a heuristic for a known pattern. The mechanics in between are far more complex than the rule itself. What the 17 software development experts did in creating the Agile Manifesto was to simplify known patterns for a complex environment.

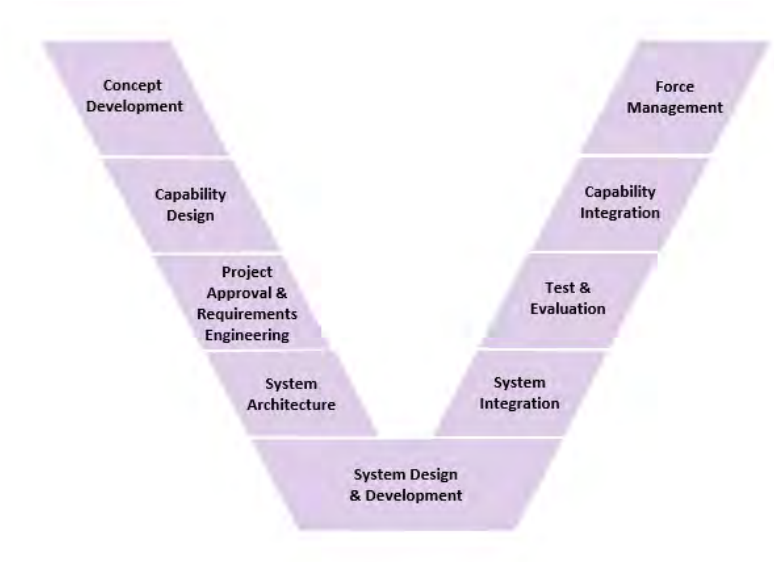

Figure 15: V model

Source: Inspired by Mitre, "System Engineering Guide: The Evolution of Systems Engineering", accessed 5 April 2021. https://www.mitre.org/publications/systems-engineering-guide/systems-engineering-guide/the-evolution-of-systems.

However, Agile is not fundamentally different from the waterfall method or any other developmental method other than it emphasizes two elements: time and teams. Figure 15 represents the V-model in system engineering, which is a sequential

[93] "How Leaders Change Culture Through Small Actions." YouTube Video 27:00 and 32:00. Posted by AcademiWales, 26 July 2016. https://www.youtube.com/watch?v=MsLmjoAp_Dg.

developmental model and an extension of the waterfall model. In the V-model the elements of the left leg correspond to the elements of the right leg of the V and vice versa. For example, requirements engineering of the left leg informs the test & evaluation of the right leg. The result of test & evaluation informs new requirements engineering. This model works well in a stable environment where the information-decision flow is quite slow as the 10 years horizons in CBP and the more than 10 years lead-time for major capital projects.

In a stable environment, whatever concept was decided in year 1 still applies in year 10. For example, we know the Canadian Army needs LAVs. Most likely, in 10 years, the concept of employment of LAVs will not fundamentally change. However, LAVs need to keep a certain level of modularity as parts of the LAVs are parts of the SoS. For example, radios will change and on-board computers as well. Softwares will change multiple times also. Those parts of the SoS need to go through the V much more rapidly than the actual platform. As discussed in Chapter 2, they need to enable emergent behaviours as their functions have to be tailored to a complex environment. In the Cynefin dynamics, in the chaotic domain when a disruptive event occurs (called a substitution event by Tushman and O'Reilly), the dynamic between chaotic and complex goes through powerful attractors such as ideas. Agile enables multiple ideas concurrently and as successful patterns are discovered, one dominant design is selected. To do so, the information-decision flow requires to be more reactive as new information from the environment or the testing of the design will trigger a new information-decision cycle.

Role-based teams

To create a reactive information-decision flow, Agile proposes to bring all the elements of the V inside one single development team. The team is divided in three roles[94]. The roles are: (1) someone capable of translating the requirements called an operator representative. This person can reach back to the operational community to get precision on the requirements as needed. (2) A leader that ensures alignment with the vision of the senior management. This person removes constraints to the team and coordinates activities. (3) The development team that produces the solution.

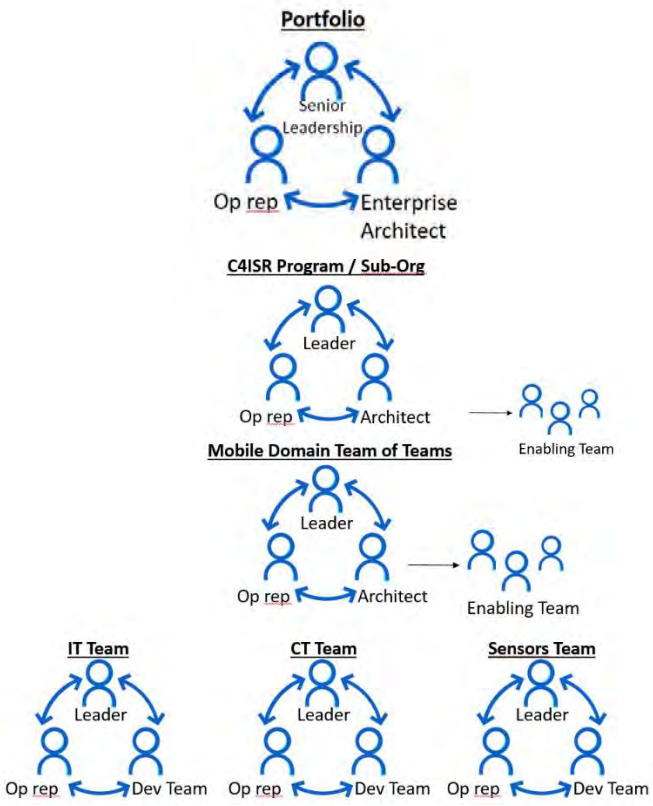

Figure 16: Role-based Model

Source: Inspired by Scaled-Agile Framework. https://www.scaledagileframework.com/.

[94] The role-based model is inspired by the Scaled-Agile Framework. https://www.scaledagileframework.com/.

These three roles apply at all levels, portfolio, program, and project. For example, as presented in Chapter 2, there are four domains in the C4ISR SoS. Every four domains of the C4ISR SoS (soldier, mobile, temporary facilities, and permanent facilities) are a team of teams joined together at the program level, the C4ISR program for instance. The three roles apply also at the team of teams and program levels. The difference is that at those levels there is no development team, but an architect and his enabling team. The architect's role is central to the technical integration of the SoS and the enabling teams maintain the knowledge management tools of the architecture. This role is absent in DND/CAF. There is a need for architects from the portfolio level down to the team of teams level. These architects reduce the ambiguity by producing key deliverables such as standards so development teams can build interoperable systems[95]. This interoperability within a SoS is important to manage the existence of legacy equipment along with emergent technologies. This is also true in a coalition context and NATO. Coalition members and NATO states often come with disparate sets of capabilities. Standards are important to ensure that interoperability can be achieved at all levels. This is also the role of the architect and the enabling team to ensure that standards are developed and followed. The team leaders and the operator representative are also important roles to increase the efficiency of the information-decision flow. The former aligns the development with the top and the latter aligns with the bottom, the operational community. However, if architects are required to be experts on a specific system, team leaders and operator representatives in the CAF context should be military personnel. The role-based model enables the use of military personnel that are staying only for a short

[95] Edward Crawley, Bruce Cameron, and Daniel Selva, *System Architecture :Strategy and Product Development for Complex Systems* (Pearson, Hoboken, 2016) : 180-2.

time in a position because roles can be replicated at many levels. The military has used the role-based model for a very long time because it is the most conducive model in a complex or chaotic environment such as war. For example, every junior officer knows the heuristics of the operations officer role. They don't need to be specifically trained for the job to understand that an operations officer coordinates the execution of his commanding officer's plan. These simple heuristics can be used in the development of SoS. Newly posted CAF members can easily fit into one of the roles without the need to go through tech staff for example. However, by definition, the movement of personnel is wasteful as the loss of information between postings is tremendous.

In a complex domain, the role-based model of Agile is efficient to reduce wastes by enabling information to be readily available. However, as new information becomes readily available, changes are required to be made in the development of the capability. Therefore, changes need to follow the flow of information-decision that the role-based teams enable. To do so, the team of teams needs to follow a specific cadence tailored to the information-decision flow.

Cadence

In the current paradigm, the cadence is 10 years. CBP works on 10 years horizons and major capital projects take a minimum of 10 years. Therefore, for a capability to go through the whole V-model, it takes currently 10 years. As previously discussed, this is too long in the current environment and for the integration of SoS. The fundamental difference of Agile versus the waterfall or V-model is the augmentation of the cadence by reducing the batch size. The batch size is the increment that a team of teams is capable of developing in a given timeframe. For example, in the current paradigm, the batch size is

huge. All of the requirements are crafted before going into development. Then, the solution is fully developed. After that, it is fully tested and validated. If a problem is found, then hopefully it is not too large since the lead-time to fix the problem is very long. In the complex domain, a team of teams could decide to have a two months cadence. That means that the team goes through the V in 2 months. To do so, it needs to reduce the batch size into smaller but tangible parts of the solution. This could be a prototype or parts of a digital application that can be tested to see if it meets the requirements. However, it does not mean that the solution is released. Release can be on-demand but development incremental.

Also, a cadence means that each increment, each team inside the team of teams, follows a plan-develop-integrate-test sequence at the same time. In the planning phase, planning sessions are organized to decide the next increment based on the capacity of the teams and the selected cadence. The planning session includes everyone in the team of teams, a maximum of 120 persons because during those sessions the team interacts to find the most efficient solution to develop the next batch. The goal is for each team to commit to achieving part of the increment. This is also the moment to use design thinking methods to bring the team of teams to the edge of chaos and back and to share the senior management vision and thus foster alignment.

Since integration is part of the increments, integration work is calculated inside the batch. This means that development work and integration work stand on the same level of importance. This is a forcing function to ensure that integration is not an afterthought, which is a problem in DND/CAF currently as stated by the former VCDS in his letter to the capability development community.

Finally, during an increment, operators test the new solution to confirm that it meets the requirements. Potentially, senior management could decide to develop multiple solutions or parts of solutions and to test them concurrently. This helps to confirm assumptions, a key aspect of abductive reasoning. This is central to Agile because it reduces significantly the risks taken by making choices too high in the hierarchy without enough information. In the Cynefin dynamics, at the moment a disruptive event occurs (or a substitution event from Tushman and O'Reilly), the decision-making model to move from chaotic to complex is the swarm. Agile enables concurrent designs, a swarm of designs, to be developed and as they are tested by trial and errors (the complex to complicated dynamic), patterns are discovered and designs are abandoned until one dominant design remains. Each of those designs is developed using the decision-making model for the complicated to simple dynamic, which is the Bayesian decision-making model. Agile is a Bayesian decision-making framework as each iteration provides more fidelity of information. But Agile also allows the use of concurrent designs, which is essential to the divergence-convergence method of design thinking.

In this sense, Agile is aligned with other execution processes at other levels. As discussed in Chapter 1, this is the key to succeeding in executing a strategy. However, by rapidly developing technology, we incur the risk that the human-system integration (HSI) is overflowed by the pace of change. This brings back the importance of VSM and the separate organization. As an end-to-end process, VSM demands that HSI is included in the separate organization. This means that training needs to be provided by the separate organization at the same rhythm than the release schedule. From a Lean perspective, a developed solution that is waiting for the training packages to be ready and taught is a waste. Therefore, the capacity to train personnel should match the pace of change that

Agile will procure. In the current paradigm, a change in the training system can take months, if not years. Also, in a high pace technological environment, can we allow troops to be retrained every two months? Obviously not. The current operational tempo is too demanding and specialist troops are in dire need everywhere in the CAF. How can we do HSI without the cumbersome process of the training system and overflowing troops in training? We need to develop a community of practices using the DevOps method.

DevOps

DevOps comes from the two words, development and operations, and stems from the Lean-Agile practices. DevOps breaks the "thrown over the fence" syndrome, where developers code and test software in an unrealistic environment, called a sandbox and then deploys it on the production environment, where it miserably crashes everything as soon as it started to be used. Readers will recognize this as a known pattern. DevOps breaks the silo between development and operations by allowing continuous delivery. Therefore, problems are found iteratively, in smaller batches, and corrected by the development team almost immediately.

DevOps is fine for software development, but the key principles of DevOps can also be used for HSI. First, in every team, the operators' representative is in charge of the HSI, especially the importance of keeping the design user-friendly. Also, in the enabling team, part of the team should be specialized in HSI, i.e. to modify the lower level doctrine such as TTPs and SOPs and provide conversion training packages if required. Therefore, from a user perspective, the DevOps principles are incorporated inside the team of teams construct. However, using technology is not the most complicated part of integrating SoS. The issue with SoS, as discussed in Chapter 2, is that they need to be

tailored to the environment. A C4ISR SoS will not be the same in a COIN environment vs a near-peer environment. Therefore, there will be considerable pressure to configure the SoS accordingly. This is also true for logistics for example. Developers cannot be asked to configure the SoS because it needs to be done on the field, a configuration can change on the fly, or events can disrupt a SoS configuration such as a cyber attack or the destruction of certain capabilities. Therefore, DevOps is also about the configurators in the case of a SoS.

More than the key principle, DevOps is mostly a culture centered on a community of practice between the developers and the configurators on the field. Information needs to flow constantly between the two communities to allow the near fusion of both. Also, DevOps are tools. Knowledge management tools that share this information efficiently and maintain the level of knowledge required to both configure and develop the SoS in an efficient manner, i.e. without waiting for formal training. The key deduction here is that CAF SoS users and configurators are not required to be fully pro-efficient in the SoS before their first posting to an operational unit. CAF schools should not be bothered with the latest technologies and tactics because changes made to formal training are very labour-intensive. Therefore, CAF schools, from a technological perspective, should focus on foundational training. Finally, conversion training provided by the SoS sub-organization should be offered when an individual arrives or comes back to an operational unit. Otherwise, to modify formal training every time there is a change in the SoS would be unfathomable and create unacceptable delays thus wastes.

Much more could have been written on Agile such as the use of the set-based approach, scrum, and Kanban. However, the three proposed characteristics presented in this chapter, represent the key elements to integrate a SoS. The role-based model breaks

the silos and enables HSI; the cadence augments our reactivity by the reduction of the batch size and enables the use of design thinking and other methods for disruptive innovation, and; DevOps bridges the developers and the operators/configurators communities to integrate human and systems.

Recently, the idea of Agile procurement started to circulate in DND/CAF. This is a step in the right direction, but at the scale of DND/CAF, having a small part of the whole organization using Agile risks creating a massive overflow in other parts. In DND/CAF, Agile cannot exist without Lean.

Conclusion

In this chapter, we presented two solutions for the issues of portfolio management and SoS integration. First, we discussed VSM as the end-to-end analysis of the information-decision flow, a central element of LPD. We recommended that sub-organizations are created for each main SoS of the CAF to match the information-decision flow. Second, we looked into those sub-organizations and defined three characteristics that are essential to be Lean-Agile: the three roles model, a cadence, and DevOps.

These are not comprehensive solutions but they chart a different way of executing a complex strategy in a complex environment. There is much more thought to be put into these issues. What SoS programs and sub-organizations should be created? What integrating functions should be included inside those organizations and what is the relationship with the other similar functions? How the Lean-Agile culture can marry with the governmental resource allocation processes? However, the one error to avoid is to segment the information-decision flow. It is primordial that the issue of SoS in the CAF

be analyzed from a holistic perspective based on the information-decision flow. The goal is to build an ambidextrous DND/CAF capable of evolving in a complex environment.

Ambidexterity and evolving in complexity demand a major culture shift from planned and mechanistic processes to a cascade of choices with the least obstacle possible. This culture shift needs to affect the way we control the process. It is unfathomable to measure every single activity of a complex process tailored for a complex environment. The only valid measure is the outcome. In-between, the information-decision flow is based on two elements: a vision that is clearly communicated from the top, and constraints that are flowing from the bottom. Fortunately, the CAF have within its command and leadership culture all these elements and the necessary mindset to succeed in a complex environment. The CAF excels in operations and in training Canadian soldiers for war, a complex environment. For instance, in training, the use of heuristics is constant: simple drills that in the heat of combat are easily remembered. In addition, mission command is much valued in the CAF whether it is practiced or not. These are all elements to succeed in a complex environment, where information is uncertain and volatile. Like Jekyll and Hyde, once we put our manager's hat on, we tend to over-control and over-process, without looking at the flow of information in the environment. This creates a disordered and wasteful environment that is not conducive to success in a complex environment.

CONCLUSION

Throughout this paper, a parallel was made between the market and war. Can war justifiably be compared to the market? Perhaps not entirely. War is seldom tested whereas the market constantly is. This is the greater challenge of capability development: There is a paucity of information to validate the capabilities. War occurs only rarely and war simulation does not fully replicate its cruel reality. On the contrary, a new product rapidly receives market feedback that is easily measurable in dollar figure. This information gap is what CBP is trying to bridge by analyzing the most likely portfolio for the future operational environment.

However, even a top-class CBP process cannot bridge a more than ten years gap in the current environment. Even if we identify a plausible threat and urgently buy a "thing" to counter it, this "thing" will not be integrated with the CAF's SoS. In the current literature, the culprit for this more than ten years gap is the bureaucratic-ridden, politically-driven procurement process[96]. Perhaps, some of the constraints of the process will be removed one day. Perhaps, a central agency for defence procurement will facilitate it. However, DND/CAF already spent hundreds of millions of dollars on a C4ISR spine and other SoS without satisfaction, because we are buying a "thing", not a capability integrated into the SoS. Also, most of the time, the procurement of components of the SoS remains under the political radar and the risk management rules of the Treasury Board, because they are not procured in large numbers, thus not very expensive.

Definitely, DND/CAF owns a large portion of the problem and the solution, and has within its authorities the means to change. An example that this statement is true, is the recent creation of the Deputy Chief of Combat Systems Integration position under the

[96] Kim Richard Nossal, *Charlie Foxtrot: Fixing Defence Procurement in Canada* (Point of View, 2016).

VCDS and even more telling, the creation of the Strategic Advisor to the CDS for Future Capabilities. This position held by the former VCDS will aim at "enhancing and expanding future interoperability of the CAF."[97] The senior leadership of the CAF understands that we have a problem and tries to find solutions.

This paper identified that the problem DND/CAF is facing is due to the misalignment of its strategy execution processes with its environment. In Chapter 1, we discussed the importance of alignment between the formulation and the execution of a strategy at all levels of the organization. Both formulation and execution also need to be aligned with the environment, the context. It has been shown that the Cynefin framework enables us to understand the relationship between the context and the way we should make decisions. The Cynefin domains differentiate the informational contexts. These drive different methods of decision-making and explain how a strategy should be aligned with its context. Moreover, the Cynefin Dynamics, the movement between the Cynefin domains, explain how strategy execution processes should be aligned, and established that the most challenging dynamic is between the complex and the complicated domains. This is where most organizations' strategy fails. They do not recognize a shift in the environment and fail to align their strategy for a complex environment. They continue to use mechanistic processes even if the environment has changed.

It is shown that an ambidextrous organization is an organization capable of moving between the ordered and unordered, between complicated and complex. This movement is essential for DND/CAF as well, to be successful in the current security and technological environment and in the execution of its pan-domain strategy.

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[97] Marcello Sukhdeo, "LGen Frances Allen appointed as the first woman Vice Chief of the Defence Staff for the CAF" (Vanguard, 9 March 2021) https://vanguardcanada.com/lgen-frances-allen-appointed-as-the-first-woman-vice-chief-of-the-defence-staff-for-the-caf/.

Chapter 2 presented two drivers for change, both drivers represent a major shift in the environment, threatening failure in the execution of DND/CAF strategy. First, the requirement to use TBP in capability development illustrated the importance of being agile in an environment where both friends and foes are accelerating the exploration of technological innovations to gain an advantage in the near-future operational environment. Second, the integration of SoS is a complex endeavour, presenting five characteristics that differentiate them from unique systems. The Boardman-Sauser framework defines those five characteristics that demonstrate the complexity in the development of SoS capabilities. SoS cannot be treated by the same mechanistic processes that was successfully used in the past by the DND/CAF to buy unique systems such as platforms. SoS are complex open systems and need to be developed with strategy execution processes capable of tackling complex problems.

Chapter 3 ventured to explain why the current DND/CAF strategy execution processes fail to meet the demand of SoS development. It concludes that there is clear misalignment between the current processes at all levels and the complexity of the environment. The use of the Stage-Gate system at the portfolio level, a process tailored for the complicated domain, is a major issue. The management of a portfolio is complex, it requires a different decision-making regime. SoS integration is also complex. Trying to integrate a SoS using project management processes, which are mechanistic, in a balanced matrix structure is doomed for failure. The use of the PRICIE+G heuristics as an analytical tool in both project management and the Stage-Gate system are not conducive to integration. The environment moves to quickly, the scale of the portfolio is too vast, and the integration touchpoints are beyond human cognition. These are clear signs of misalignment of complicated processes in a complex environment.

Chapter 4 proposes the use of Lean-Agile as a potential solution, but focusing the effort of elements of Lean-Agile that meet the criteria of the Cynefin dynamics. These elements are first, an ambidextrous organization structure that significantly reduces wastes in the information-decision flow by applying a VSM analysis. Second, sub-organizations that have three main characteristics: a role-based model, a cadence, and DevOps. These characteristics from Agile are heuristics or patterns that enable to cross from the complex Cynefin domain to the complicated and simple domains. This proposed solution is not complete, but presents a way forward. However, it is primordial that DND/CAF do not lose the focus on streamlining the information-decision flow. Many Lean-Agile frameworks propose a complete solution. In implementing those solutions, we should never forget why we are doing it and remain cognizant of the Cynefin dynamics.

Mostly, any of those changes is a major shift from the way we are developing capability currently. Adopting a Lean-Agile framework in an ambidextrous DND/CAF is a formulated strategy by itself that will require a good alignment with its execution processes. This paper discussed neither how this change should be executed, nor the cultural challenges of executing such a major shift. One thing for sure, it will create discomfort. However, this discomfort will appear trivial in comparison to the discomfort of sending unprepared troops in the near-future operational environment. The use of drones and AI are clear examples of the lack of preparedness of the CAF that any member of the Canadian profession of arms can readily agree is in a dire state. There is an urgency to change and there is also an urgency to understand that change is the constant in this environment. Our center of gravity is our ability to timely adapt to this changing environment and only the alignment of strategy execution processes will

successfully bring us to an acceptable state. We do not have another 10 years to re-align ourselves.

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