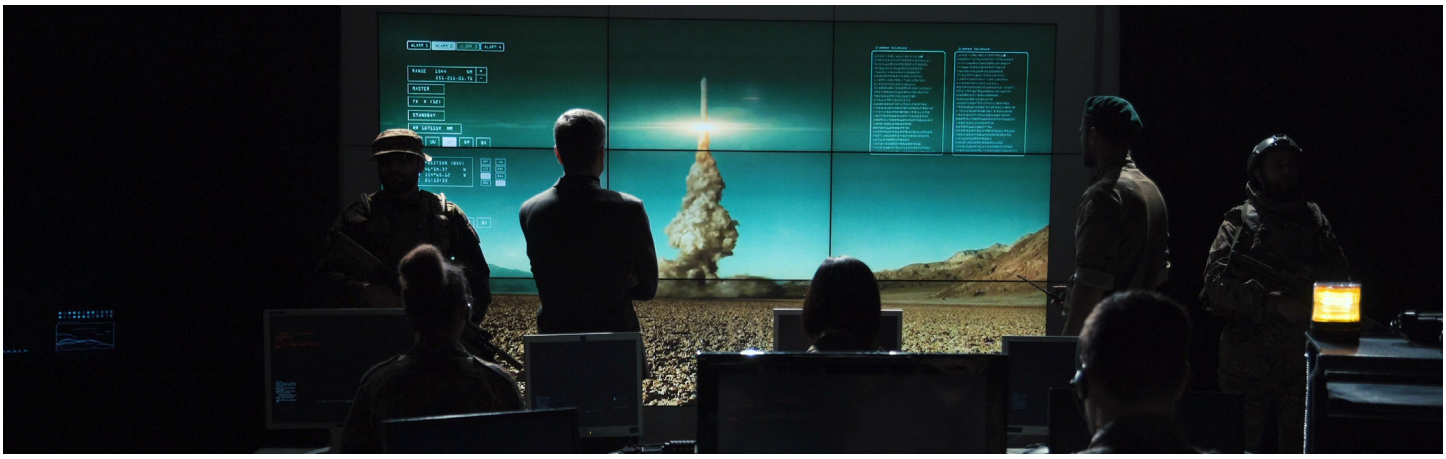

Operations and opportunities in command and control

The digital revolution comes to the Canadian Armed Forces

The digitalization sweeping across the Government of Canada gets a little tricky when it comes to national security and defence. All efforts must meet the requirements of both the Canadian Armed Forces (CAF) and the Department of National Defence (DND)—and, while interconnected, the CAF has distinct military needs.

The ultimate goal for the CAF on this digitalization journey is to achieve pan-domain command and control, known as PDC2. A PDC2 environment is one that links sensors, weapons platforms, and decision-makers throughout the battlespace to a common network. This enables the pooling and harnessing of data that, when analyzed using machine learning (ML) and artificial intelligence (AI), produces relevant operational insights to inform decisions and helps drive operational effects at the high speed of contemporary operations.

Moving toward a PDC2 environment is critical for Canada to remain interoperable with its allies, who are on their own digitalization journeys. It will also allow the CAF to take full advantage of the modern, networked capabilities it will be fielding over the next decades (F-35s, Aurora replacements, ground-based air defence, surface combatants, etc.). In the aggregate, PDC2 is an essential capability to regain operational advantage against more advanced adversaries, contribute to the maintenance of deterrence, and protect the interests of Canada and Canadians.

At home and among our allies, there are those who question whether PDC2 (or, in the US parlance, joint all-domain command and control, or Australia's joint command and control) is fully achievable. There are legitimate considerations about the maturity of technology, the adequacy of data strategy and governance, the pace of technological change, and the cost. In Canada, geography also presents a formidable challenge to rolling out a 100%-connected PDC2 environment across the country, let alone around the world.

However, PDC2 is not an all-or-nothing proposition. Every advance in networked capabilities or sets of cross-domain insights will provide a net benefit to the CAF. It will become more "joint" and its domain boundaries will blur, which will increase interoperability between our forces and those of our allies.

We contend that the journey is worth the effort. PDC2 is the goal, but the work to reach it—the building of the policy, infrastructure, and networks to form the digital backbone that will make it possible—will present myriad opportunities to modernize and improve. Because as well as being a systems integration challenge, PDC2 is an operational, organizational, and human-capital optimization challenge. And as such, it will require deliberate, careful consideration of where to start and how to advance.

Domains

First, a word on domains and the concept of pan-domain. There are three traditional areas, or domains, in which warfighting occurs: land, sea, and air. These gave rise to our familiar service structure of army, navy, and air force, each tailored to the environment in which it operates. However, technological advancement has expanded where warfighting and competition take place. Thus, space and cyber have been elevated to domain status as areas that must be defended and exploited to prevail over potential adversaries. In recognition of this fact, the United States, for one, has added a space force to its services. There is also talk of information, cognition, and even the electromagnetic spectrum as being domains. What's important is that a pan-domain approach means collecting information from, making sense of, and directing integrated action across all relevant domains.

"Space and cyber must be both protected and utilized—or else data crucial to winning on the ground, in the air, and at sea will be unobtainable."[1]

General (Ret'd) John E. Hyten, former vice chair of the US Joint Chiefs of Staff

PDC2: An overview

The imperative to digitalize for operational advantage is a common theme among Canada's allies. While there are differences in emphasis and conceptualization, the common approach is to connect sensors from all domains to a single information network and then use this networked system of systems to produce meaningful effects. Broadly, these effects can be broken down as follows:

- **All-domain awareness**. This effect is achieved by creating a network of sensors that ideally extends from the sea floor through the atmosphere and into space and cyberspace. This suite of networked sensors and collectors provides a steady, uninterrupted flow of information about events throughout the battlespace. The United Kingdom has referred to this as creating a single information environment, or SIE.[2]
- **Information dominance**. Capitalizing on an SIE, a PDC2 system is able to rapidly ingest, aggregate, process, display, and disseminate data, enabled by the application of AI and ML.[3] This delivers high-quality and reliable information that commanders can access to understand what's happening and make sound decisions.
- **Decision superiority**. A force that can exploit persistent all-domain awareness to maintain information dominance can use this knowledge to identify targets, analyze and anticipate possible adversary moves, and recommend a set of appropriate actions, potentially taken and coordinated across multiple domains. A military that has consistently achieved these has achieved pan-domain command and control.

Without the application of AI and ML, command and control is labour-intensive and cognitively complex.[4] These technologies have the potential to considerably reduce this workload by providing machine-speed insights and decision support to commanders. The key here is to do it faster and more accurately than an adversary.

"The joint command and control system is our most important warfighting system. It is the glue of the joint fight, turning individual capability elements into a synchronized, coherent force delivering an operational edge to Australia."[5]

Lieutenant-General Greg Bilton, chief of joint operations of the Australian Army

Opportunities for AI- and ML-driven systems

Achieving pan-domain command and control will require creating a connected system of systems that can also operate in dispersed, austere, and sometimes contested environments at various levels of classification, up to top secret. The building blocks of such a system include a stable, resilient, and secure data backbone, a common data fabric, a robust application layer, and an adapted workforce.

Decision support in the air domain

A quick-win example of a typical PDC2 application is Pathfinder. This cloud-enabled application is expected to provide profound benefits to the North American Aerospace Defence Command (NORAD), whose primary job is to understand what is happening in the air domain over the continent. Pathfinder uses AI and ML to fuse and declutter information from multiple aerospace sensors, making sense of what is otherwise an extremely complex picture generated by multiple radar feeds.

As an example of its capabilities, Pathfinder was used to solve the mystery of where an ultralight aircraft that landed undetected and without warning on the front lawn of the White House in 2015 came from. The app drew relevant data from more than 300 sensors and decluttered it to clearly reveal the errant aircraft's flight path.[6]

In a similar manner, with a cloud-based information infrastructure, battlespace data from all domains can flow to a single source of truth to generate otherwise unattainable insights. The CAF can use cloud-enabled AI and ML systems to collect and analyze surveillance data feeds from all domains. This will permit the use of smart sensors to track and detect objects or personnel. Additional integration with allied military systems and open-source data, including satellite and drone surveillance data feeds, will provide a clearer picture of a conflict or crisis dynamic than can be achieved through human-only efforts. Analysis can be deepened by bringing in more information, such as historical mission data, supply states, health data, environmental factors, and asset data such as maintenance states.

> "Our information and communication services will underpin the single information environment (SIE) and must have shared, ubiquitous standards, be backward compatible, and able to connect to unanticipated partners, as well as established allies."[7]
>
> **UK Joint Concept Note 2/17: Future of Command and Control**

Decision support for sustainment

The CAF can use available surveillance data and ML algorithms to better anticipate resourcing requirements and associated costs for missions and training exercises. With the use of a cloud platform, the CAF can easily access all-domain data to enhance the planning stage, supported by reinforcement learning algorithms that perform reconnaissance and discover logistic bottlenecks as well as better opportunities for new sources of supply, improved logistics flow, and cost savings.[8]

An applicable example from the commercial world would be a camera on a flight line that counts aircraft and classifies them. In a military context, that data could then be sent to a dashboard and combined with manifest information to help logistics planners not only track aircraft arrivals and departures, but also prioritize the flow of commodities and combat supplies into the airport, plan for forwarding to operating areas, and even establish aircraft loading priorities, whether it be personnel, food, or munitions.[9]

Empowering logistics in operations

As different assets rely on each other to form the needed capabilities, timely recommendations can significantly improve field operations.[10] For example, an aircraft needs multiple inputs to operate effectively (aviation fuel, munitions, replacement parts, encryption, navigation satellites, etc.). Cloud-enabled AI has the power to provide real-time data to enhance aircraft field operations by identifying missing spares, consumables, or code, and recommending how to get the necessary assets from multiple domains and locations.

Learning from others

Many of Canada's allies are well into their digitalization journeys. The CAF can use many of those public and classified lessons to assist its own endeavours. One such lesson is the importance of carefully prioritizing initial programs at the outset. For example, the initial plan for the United States Air Force's (USAF) Kessel Run program (a grouping of seven programs that combined acquisition and operations to make up, in effect, a scalable software factory to architect, manufacture, and operate warfighting systems to function in highly contested environments) was to automate the operational targeting process within USAF Central Command Headquarters (AFCENT). However, due to the complexity, lack of clean data, and absence of a clearly articulated targeting process, plans were changed. The Kessel Run staff had noticed a number of junior aviators manually assembling the aerial re-fuelling plan using magnets and dry erase markers on a whiteboard. The staff then convinced leadership to prioritize automating this task instead.

The CAF could initially focus on quickly building basic capabilities, ones that will deliver immediate value to its workforce, rather than the more complex programs that will ultimately benefit a few senior decision-makers.

Once the automation process was finished, what had taken six people eight hours of work every week was now done by one person in three hours using a simple touchscreen interface. Aside from being a significant time saver, the optimized refuelling profiles and schedules saved AFCENT 400,000 to 500,000 pounds of fuel, the associated carbon emissions, and US$750,000 to US$1 million every week.[11]

Keeping this lesson in mind, the CAF could initially focus on quickly building basic capabilities, ones that will deliver immediate value to its workforce, rather than the more complex programs that will ultimately benefit a few senior decision-makers. The destination of digitalization—a complex and interconnected-by-design system of systems—doesn't have to be reached only by highway; side roads can yield just as much.

A PDC2 environment will not only enhance the command, control, and conduct of operations, but also the sustainment and support management of operations. PDC2 infrastructure can be used to allow the CAF to adopt or mirror best practices from industry to address the many challenges of supply chain planning, warehousing, resupply, maintenance, infrastructure management, qualification and readiness management, and health care, among others.

While PDC2 is the main operational objective, the institutional value of a modernized Canadian Forces Health Information System (CFHIS), a user-friendly Defence Resource Management Information System (DRMIS), and a Defence Wide Area Network (DWAN) with limited technical debt cannot be ignored.

An opportunity to modernize the CAF workforce

The PDC2 environment is also an opportunity for the CAF to drive change in its workforce. Similar to the Kessel Run example, by automating formerly manual and labour-intensive task such as claims processing, logistics management, and warehousing, the CAF can reallocate personnel from legacy management and support structures to emerging high-priority missions. The implementation of new technologies like cloud computing, a DevSecOps (development, security, operations) approach to software production, and the overall "Internet of Military Things" (IOMT) will require the CAF to develop talent with modern skill sets, such as DevSecOps engineers, site reliability engineers, and data scientists.

To address its current scarcity of critical skills and competencies, the CAF will have to consider modifications to its force structure (the distribution of personnel between units and geographies), its military occupation structure (MOS) (the structure of its trades and occupations), and its approach to recruiting. Its talent attraction and management strategies will need to be updated to attract a new generation, and possibly include outsourcing or purchasing missing skills and products as a service.

Beyond the new skills required to directly support its PDC2 transformation, the CAF must provide the tools, skills, and processes that its entire workforce will need to thrive in a digitalized environment. A lack of access to modern digital tools to perform work has already been identified as a significant driver of attrition.[12] This will only become more important as more naturally digitally savvy generations move into positions at all levels throughout the organization, including the most senior leadership.

MOS-specific training and professional military education needs must also be considered. All leaders within the organization, not just the digital specialists, will need to be trained in how to understand the potential of PDC2 and its digital effects, just as they learn how to understand weapons effects, aircraft capabilities and limitations or to plan for combined and joint operations. This will not be a one-time event but a career-long learning journey.

Finally, the CAF must re-imagine its internal processes, structures, and governance to fully realize the possibilities afforded by a cloud-based, AI/ML-enabled PDC2 environment. The Royal Canadian Air Force (RCAF) has taken the first steps to this kind of approach with its Flight Deck Innovation Lab and Plan Qulliq. Capitalizing on the Communitech Hub in Kitchener, Ontario, these two initiatives have identified pain points from RCAF front-line operators and used a small team of students to produce cloud-based applications to enhance RCAF operations. Notable among the apps produced so far by Flight Deck is Dispatch, a mission-planning platform for the air mobility community. It helps to plan operations like aircraft handling, fuelling, customs, itineraries, and crew lists, which had been managed through a buggy, complex, and irregularly maintained database.[13]

Key to the success of this initiative is the deliberate decision by RCAF leadership to short-circuit traditional hierarchies by facilitating a flat, bottom-up approach to identify and fund good ideas, using a DevSecOps approach to software development, and encouraging risk-taking across the organization. The CAF would be well-advised to consider replicating this kind of culture change and process.

The opportunities of digital revolution

A PDC2 environment requires much more than just hardware, and enables much more than just command and control. The journey toward PDC2 will present myriad opportunities to enhance business processes and realize efficiencies in operational support throughout the CAF. It will also necessarily drive changes to the organization's workforce.

Fortunately, leadership doesn't need to reinvent the wheel to become a data-driven, AI/ML-enabled enterprise and to build a PDC2 environment. It can look to both allies and industry for examples of how best to approach its digitalization journey and get a great return on investment in the process. This journey must start and be managed with a focus on strategic enterprise goals and a clear strategy and operating model design. With this base established, the identification and operationalization of AI delivery capabilities that can quickly generate results for warfighters comes next. Combined with data governance and modernization, this will ultimately serve to deepen the practical insights modern commanders require.

While PDC2 is the goal, there are many side benefits, including enhanced supply-chain planning, warehousing, resupply, maintenance, infrastructure management, and health care. The CAF already understands that focusing only on the technology and applications is not enough to realize a good return on investment for digital transformation. It must work to transform its workplace, its operating model, and its culture to achieve the interoperability, pan-domain awareness, information dominance, and decision superiority that it requires to keep Canadians safe in this increasingly unpredictable world.

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