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Politics, policy and industrial considerations in the **Canadian Surface Combatant Program**

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TRUE NORTH
IN CANADIAN PUBLIC POLICY

Contents

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Executive Summary

It is difficult exaggerate the scale and complexity of the Canadian Surface Combatant (CSC) shipbuilding program; if executed as envisioned, it will cost at least $60 billion and become the largest public procurement project in Canada's history. While the project has selected the Global Combat Ship hull design from BAE Systems, essential parts of the ship's design must still be developed, including integrating sensors, control, and weapon systems.

The Canadian Surface Combatant program has been the subject of growing controversy over its cost, capability, and delivery dates. In the public's eye it has become another in a string of serious procurement failures that have afflicted the Canadian government for the past 15 years. But peel back the curtain a bit and a different picture emerges. The CSC program has indeed had missteps, but the outcomes are reasonable considering the challenges it has faced. This paper explains how the program emerged and what its progress has been to date.

The genesis of the Canadian Surface Combatant program began in the 1990s when the Royal Canadian Navy (RCN) began planning to replace four *Iroquois*-class (also known as the *Tribal*-class) destroyers and twelve *Halifax*-class frigates. In addition to replacing the major surface combatant ships, the RCN also needed to replace its three Auxiliary Oiler Replenishment (AOR) vessels.

Unfortunately, due to the decade-long gap in shipbuilding during the 2000s, the federal government's acquired knowledge and experience for complex project management atrophied. The National Shipbuilding Procurement Strategy (NSPS) was a response to the Navy's need to replace key vessels and develop the ability to successfully construct them. The NSPS's first step was to hold a competition to select a shipyard that would produce the vessels, which Irving Shipbuilding eventually won. It would later become the prime contractor for the project, which was a significant change to its management structure.

The CSC then moved to the development, engineering, and production phase. The RCN decided to procure an existing naval design and then modify it to suit its requirements. Twelve groups participated in the early CSC information sessions that the government organized and four bids were anticipated. On October 8, 2018, the BAE Systems-Lockheed Martin team was selected as the winner. As the prime contractor, it was responsible for negotiating with the BAE-LM team on the design. This added level of management likely contributed to one of the CSC's more intractable issues in the public's view: escalating cost estimates. Having said that, acquisition costs are difficult to estimate. The Deparment of National Defense (DND) has stood by its $60 billion assessment, but several other groups have suggested that the cost will be much higher.

To address the problem of the program's increasing costs and slipping delivery date, some observers have made well-meaning suggestions. They include re-competing the design award, purchasing a less capable class of warship to complement a truncated purchase of the Global Combat Ship, or simply just purchasing fewer vessels. Unfortunately, none of these ideas are likely to decrease the cost of the ships to Canada in any meaningful way. For example, if the government abandoned the Global Combat Ship and selected a different design, or purchased a complementary class of less capable warships, it would need to invest heavily to transform that design into a ship that would meet the needs of Canada's Navy. And starting anew with a different design would still take a decade to implement. Delay in obtaining replacements for the *Halifax*-class would require costly life-extension refits to those vessels and subsequent higher operating costs. All of these factors would erode any potential cost savings that might initially make some of the alternative ideas appear attractive, and would delay the badly needed modernization of the Navy.

The experience with the CSC provides lessons for other defence programs. Understanding just how those circumstances emerged and how they affected not just the CSC program but how they will affect other, future programs – such as the replacement for the RCN's *Victoria*-class submarines – is a worthwhile objective that can improve outcomes for Canada and the Canadian Armed Forces.

Sommaire

Il est difficile d'exagérer l'échelle et la complexité du programme des navires de combat canadiens (NCC) ; s'il est réalisé tel qu'envisagé, il coûtera au moins 60 milliards de dollars et deviendra le plus important projet d'approvisionnement public de l'histoire du Canada. Bien que le projet ait retenu le modèle « *Global Combat Ship* » (navire de combat mondial) de *BAE Systems*, certains de ses éléments essentiels doivent encore être mis au point, y compris l'intégration des capteurs, des commandes et des systèmes d'armement.

Le programme des navires de combat canadiens est devenu un sujet de plus en plus controversé en raison de son coût, de ses capacités et de ses dates de livraison. Aux yeux du public, il ne constitue qu'un échec de plus dans la série d'échecs graves en matière d'approvisionnement qui afflige le gouvernement canadien depuis 15 ans. Or, en levant un peu le voile sur le projet, une image différente apparaît. Le programme NCC a effectivement connu des ratés, mais les résultats sont jugés raisonnables compte tenu des défis relevés. Le présent document explique comment le programme est né et décrit les progrès accomplis jusqu'à maintenant.

La genèse du programme des navires de combat canadiens remonte aux années 1990, lorsque la Marine royale canadienne (MRC) a commencé à prévoir le remplacement de quatre destroyers de la classe *Iroquois* (également appelée « *Tribal* ») et de douze frégates de la classe *Halifax*. La MRC devait également remplacer, en plus de ses principaux navires de combat de surface, ses trois pétroliers ravitailleurs d'escadre.

Malheureusement, en raison de l'absence décennale de construction navale pendant les années 2000, le savoir-faire acquis par le gouvernement fédéral en matière de gestion de projets complexes s'est atrophié. La Stratégie nationale d'approvisionnement en matière de construction navale (SNACN) a permis de répondre aux besoins de la Marine royale canadienne en nouveaux navires essentiels et en capacité de construction navale. La SNACN a d'abord prévu le lancement d'un concours pour sélectionner le chantier naval qui construirait les navires, concours que la société *Irving Shipbuilding* a éventuellement remporté. Elle deviendrait ensuite l'entrepreneur principal du projet, imprimant un changement important dans sa structure de gestion.

Le programme des NCC est ensuite passé à la phase de développement, d'ingénierie et de production. La MRC a décidé de choisir un modèle de frégate existant, puis de le modifier pour répondre à ses exigences. Douze groupes ont participé aux premières séances d'information sur les NCC organisées par le gouvernement, qui prévoyait que quatre soumissionnaires répondraient à l'appel d'offres ; le 8 octobre 2018, *BAE Systems* associé à *Lockheed-Martin* remportait la mise. En tant qu'entrepreneur principal, la charge lui revenait de négocier la conception avec l'équipe BAE-LM. Ce niveau de gestion supplémentaire a probablement contribué à l'un des problèmes les plus insolubles auxquels les NCC ont fait face aux yeux du public : l'escalade des estimations de coûts. Quoi qu'il en soit, les coûts d'acquisition sont toujours difficiles à estimer. Le MDN a maintenu son évaluation de 60 milliards de dollars, mais plusieurs autres groupes ont indiqué que le coût sera beaucoup plus élevé.

Pour remédier à l'augmentation des coûts du programme et à l'allongement du délai de livraison, certains observateurs ont fait des suggestions bien intentionnées. On propose notamment de lancer un nouveau processus concurrentiel pour un autre modèle ou d'acquérir une classe de navires de guerre moins performants en complément d'un modèle « *Global Combat Ship* » tronqué ou, encore, tout simplement, d'acquérir un moins grand nombre de navires. Malheureusement, aucune de ces idées n'est susceptible de réduire notablement le coût des navires pour le Canada. Par exemple, si le gouvernement abandonnait le *Global Combat Ship* et choisissait un modèle différent ou une classe de navires de guerre d'appoint moins performants, il devrait investir massivement pour transformer ce modèle en un navire répondant aux besoins de la Marine royale canadienne. En outre, une nouvelle conception prendrait encore une décennie à mettre au point. Si l'on tarde à remplacer les navires de la classe *Halifax*, il faudra procéder à de coûteux réaménagements pour prolonger leur vie utile et supporter des coûts d'exploitation plus élevés par la suite. Tous ces facteurs éroderaient les économies potentielles qui pourraient initialement rendre certaines des solutions de rechange attrayantes, et retarderaient l'indispensable modernisation de la Marine.

L'expérience en matière de NCC permet de tirer des leçons pour d'autres programmes de défense. Comprendre comment ces circonstances sont apparues et comment non seulement elles ont influé sur le programme des NCC, mais influeront aussi sur les programmes futurs – comme le remplacement des sous-marins de la classe *Victoria* de la MRC – est un objectif valable qui peut améliorer les résultats pour le Canada et les Forces armées canadiennes.

That in the opinion of this House, in view of her great and varied resources, of her geographical po-sition and national environments, and of that spirit of self-help and self-respect which alone befits a strong and growing people, Canada should no longer delay in assuming her proper share of the responsibility and financial burden incident to the suitable protection of her exposed coast line and great seaports.

– Resolution calling for the creation of the Canadian Naval Service by the Honourable George Foster, March 29, 1909

At the turn of the 20th century, the Dominion of Canada faced a major security dilemma. The British empire faced a growing threat from Kaiser Wilhelm's Germany, particular in the naval realm. In 1906, the Royal Navy had introduced a revolutionary new class of warship, the dreadnought, which made all other capital ships obsolete and reset the playing field. The Imperial German Navy followed suit, building its own dreadnoughts and setting off an arms race between the two powers (Taylor 1995). Britain was wracked with debates about how much to spend to ensure it maintained its quantitative advantage over Wilhelmine Germany. Within Parliament, the dispute was boiled down to a jingle: "We want eight and we won't wait," where members of the incumbent Conservative party agitated for an expanded manufacturing program to counter a potential German building program (Taylor 1995).

The repercussions of this debate crossed the Atlantic and landed on Canada's shores. In Ottawa, politicians debated the best approach for dealing with the challenge from Germany. The incumbent Liberals under Wilfrid Laurier had passed the *Naval Service Bill* creating the Naval Service of Canada in 1910, but the issue became increasingly important as the Anglo-British naval race heated up (Sarty 2018). In 1911, the issue of warships for the navy featured prominently in that year's federal election. Laurier's Liberal Party proposed to spend $3 million to fund the construction of 11 ships in Canada, which would establish a modern domestic naval shipbuilding industry. The opposition Conservatives under Robert Borden disagreed, and suggested that Canada should simply send its resources to Great Britain if war broke out. Borden's Conservatives won the election, but their plan was ultimately stymied by the Liberal-dominated Senate. The issue remained largely unresolved until the

outbreak of the First World War when the then-renamed Royal Canadian Navy (RCN) saw a major expansion.

Over 100 years later, Canada once again finds itself in the midst of a great power competition between its major ally (the US) and a rising power (China). While the RCN is well established today, the amount that Canada should contribute has become a more contentious issue. The current debate can be boiled down to a single program – the Canadian Surface Combatant (CSC) program – which will provide the backbone of the RCN's combat capability for much of the 21st century.

It is difficult exaggerate the scale and complexity of the CSC program; if executed as envisioned, it will cost at least $60 billion and become the largest public procurement project in the country's history. The next most costly military procurement is the Future Fighter Capability Project (FFCP), which seeks to replace Canada's fleet of aging CF-18 fighter jets with 88 aircraft. Acquiring replacement fighter jets is expected to cost $10 billion – a fraction compared to the CSC (Canada, Department of National Defence 2021b).

Replacing the fighters is also a fairly straightforward procurement exercise and is broadly representative of most of the procurement projects that Canada's government undertakes. With the FFCP, Canada will purchase a capability that is essentially completed and will require relatively little modification. The Canadian Surface Combatant procurement project is significantly different. While the project has selected the Global Combat Ship hull design, essential parts of the ship's configuration must still be developed, including integrating sensors, control, and weapon systems.

Like the plan to replace the fighters, however, the CSC project has been the subject of growing controversy over its cost, capability, and delivery dates. In the public's eye, it has become another in a string of serious procurement failures that have afflicted the Canadian government for the past 15 years; a "potential fiscal disaster" as one journalist has put it (Pugliese 2020a).

But peel back the curtain a bit and a different picture emerges. The CSC program has indeed had missteps, but the outcomes are reasonable considering its challenges. It is well worth the time and effort to explain how the program emerged and what its progress has been to date. This paper will discuss five considerations that are critical for explaining the present and future state of the CSC program:

1. The government's desire to reestablish a sustainable domestic shipbuilding industry to deliver the federal fleets.

2. The need to equip the RCN with highly advanced warships that are interoperable with those of our closest allies and will be able to operate

effectively well into the second half of the 21st century.

3. The state of the government's project management capabilities, which have declined since the last major shipbuilding project in the 1990s and have been hamstrung by government procurement policies.

4. The unique role that Irving Shipbuilding has played as an integrated prime contractor, which has created an additional layer of project management within the program.

5. A changing procurement and political landscape that has created incentives for losing firms to lobby decisions in order to get them overturned.

The combination of these factors explains much about the way in which the CSC program has unfolded over the past few years. This includes the selection of the BAE-LM Global Combat Ship design (jointly developed by BAE Systems and Lockheed Martin, commonly referred to by its Royal Navy Designation Type 26), the unique management and production process, the escalating cost estimates and delays, as well as other issues. Understanding the CSC's history may help with the project's future and that of other defence procurements in Canada.

The state of the Royal Canadian Navy: 1980 to present

The genesis of the Canadian Surface Combatant program began in the 1990s when the RCN began planning to replace four *Iroquois*-class (also known as the *Tribal*-class) destroyers. At that time, planners assumed, among other things, that the notional service life for surface vessels was an average of around 25 years.[1] However, service life upgrades could extend that by roughly a decade, though those upgrades usually came with reductions in the vessels' relative operational capability compared to the then-current threats and significantly higher operating costs due to the need to maintain the older systems (MacDonald 2004, 34; Martin et al. 2018).

The *Iroquois*-class destroyers first entered service in 1972, but the ships were substantially upgraded in the early 1990s (a program known as TRUMP – Tribal Class Update and Modernization Program) to adapt them to be anti-air warfare (AAW) destroyers. Almost every major weapon, sensor, and electronic-related sub-system was updated or replaced on these ships. The TRUMP upgrade gave the vessels another 10 to 15 years of viable service life, thus requiring that they be replaced after 2010.[2]

The *Halifax*-class frigates, on the other hand, are much newer multi-purpose warships that entered into service in 1992 (Canada, Department of National Defence 2018). They underwent two significant modernizations since 2006: the Halifax-Class Modernization (HCM), which updated sensor, electronics, and weapon systems; and the Frigate Equipment Life Extension (FELEX) that addressed the ships' marine systems to ensure their seaworthiness and improve their performance (Canada, Department of National Defence 2020). The modernization of the *Halifax*-class frigates was nowhere near as radical as the TRUMP upgrades to the *Iroquois*-class destroyers, because the combat role of the *Halifax*-class ships was not altered. Nevertheless, the HCM and FELEX programs significantly improved the capabilities of the frigates, allowing them to operate effectively until sometime after the mid-2020s (MacDonald 2004). However, that meant planning for the replacement vessels needed to start sometime around 2010 in order for the transition to be orderly.

In addition to replacing the major surface combatant ships, the RCN also needed its three Auxiliary Oiler Replenishment (AOR) vessels – HMCS *Provider*, HMCS *Protecteur*, and HMCS *Preserver* – to be replaced. AORs were critical for both enabling the navy to have a global presence and providing logistical capabilities for Canadian and allied surface combatants. They were also employed occasionally as logistics, communications, and command hubs for land operations, including during the Gulf War and operations in Somalia, a requirement their successors also needed to fulfill (Canada 1997, vol. 1, p. 51; vol. 3, p. 901). HMCS *Provider* was retired in 1998, while the two other ships continued to operate into the 2010s despite their advancing age and declining capabilities. The RCN had envisioned building three or four large replacement vessels in the early 2000s, which would have provided a modest increase in capabilities. This plan, launched in the early 1990s, was called the Afloat Logistics and Sealift Capability (ALSC), and plans for it had progressed steadily into the 2000s (Szeto and Cooper 2005, 12).

The Paul Martin government recognized the Canadian Armed Forces (CAF) needed significant recapitalization after the period of austerity between 1993 and 2003. This was outlined in the federal government's 2005 defence policy statement, which offered high level guidance for the start of a naval shipbuilding program (Canada, Department of National Defence 2005). However, Prime Minister Martin's minority government had a tenuous hold on power and was unwilling to provide the requisite funding for the military capabilities outlined in its own defence policy document (Hillier 2015, 348).

The federal government's overall reluctance to fund the armed forces changed in 2006 when the new Conservative government under Stephen Harper prioritized recapitalizing the military. The government's plans culminated in the 2008 *Canada First Defence Strategy* (CFDS) (Canada, Department of National Defence 2008). In the high level political and military discussions that preceded the CFDS's drafting, planners focused on the need to offer

innovative solutions for defence problems.[3] The Navy obliged, providing a comprehensive blueprint for its future naval recapitalization efforts. It would procure a single hull design for all of its future combatant warship classes. The first three vessels of this common hull would be adapted for the AAW role that would be left vacant when the *Iroquois*-class destroyers retired in the next decade. The subsequent 12 multi-purpose ships would replace the *Halifax*-class frigates sometime after 2020. By agreeing to a common hull design, all parties involved hoped to decrease the costs associated with acquiring and operating the vessels.

The CFDS also called for a third class of vessel to be constructed, an Arctic and Offshore Patrol Ship (AOPS). The AOPS was a completely new type of warship intended to operate in northern latitudes, as global warming had increased the ability for civilian and military vessels to operate in Arctic waters. Improving the RCN's Arctic capabilities was a stated priority of the Conservative Party even before the 2006 federal election (CPC 2006), and it announced the AOPS the following year. CFDS essentially confirmed the AOPS as a priority for future production. Defence policy white papers and statements should be viewed as more than a blueprint – they are also bureaucratic tools. Groups within government expect to use them to justify their expenditures and push along the process and the plans they outline. That was certainly the RCN's hope; it thought the statement would finally allow for progress on the four major programs it desired.[4]

> *"Defence policy white papers ... should be viewed as more than a blueprint – they are also bureaucratic tools.*

Unfortunately for the Navy's ambitions, many of the assumptions upon which CFDS rested were undermined in the coming years. 2008 marked the depths of the subprime mortgage crisis and with it the massive fiscal stimulus spending designed to prevent a new Great Depression. The cyclic nature of such spending meant that the government's fiscal room was diminished in the mid-2010s, approximately at the same time as many of the shipbuilding programs were about to ramp up.

Furthermore, at that time Canada was entering into a series of high intensity deployments to Afghanistan as part of NATO's International Security Force. Sustaining that contribution vastly increased the operation and maintenance budgets for the Army and Air Force, concurrently reducing the budget available for capital projects. This alone may not have derailed the plans for the replacement frigates, but it was exacerbated by changes in procurement pri-

orities due to Afghanistan's immediate operational needs. The government launched several urgent acquisition programs for capabilities related to combat operations in that country. These included a new lightweight artillery system, improvised explosive device resistant vehicles, mine detection equipment vehicles, helicopters, transport aircraft, and the Leopard II tank.

The seeming alacrity with which these programs were advanced led many outside the Materiel Group (the CAF's procurement organization) to assume that these items were acquired through sole-source acquisitions. This assumption was incorrect – all but one of the programs went through the full procurement process, which included a competition.[5] This was despite the desire from within the department to find ways to deliver these capabilities rapidly, as many would not arrive in time to be deployed for Canadian operations in Afghanistan.[6]

These issues were exacerbated by the ascendance of General Rick Hillier to the position of Chief of the Defence Staff (CDS). His blunt yet effective style upset a number of individuals and likely gave rise to the view that the Department of National Defence (DND) ran roughshod over procurement processes (Hillier 2015, 411). Moreover, while he was an enthusiastic supporter of the CAF's recapitalization, he had very specific views about the role the Forces would play internationally. Under his leadership, the military saw a major reorganization towards land-based stabilization missions, beyond the immediate needs of Afghanistan.

Nowhere was this more apparent than with the AOR replacement program. Now known as the Joint Support Ship (JSS), the Navy had scaled back some of its ambitions, and sought a somewhat smaller ship that was less capable of supporting land operations than had been originally envisaged in the ALSC program (Canadian Naval Review 2010). This included a smaller vehicle deck capacity and an ability to dock in austere environments. These decisions deleveraged risk by reducing the ship's complexity and capability, which made it more likely the JSS could be delivered on time and on budget. In June 2006 the government released its request for proposal (RFP) for the AORs.

While Hillier understood the RCN's desperate need for an AOR replacement, he nevertheless still pushed the Navy to acquire ships that would also support land-based operations (Hillier 2015, 407). The CDS landed on what he colloquially called a "big honking ship," more commonly known as a landing platform dock for amphibious operations. This new class of warship would carry four to six heavy-lift helicopters and a battalion of approximately 800 to 900 soldiers (Smith 2005).

Hillier's request that the Navy consider an entirely new class of warship further strained staff resources and promised to stretch the already thin budget within DND. It almost certainly affected the JSS program. Despite the efforts

in the RFP to curtail the program's objectives, none of the bidders was able to meet the mandatory requirements and deliver three ships under the $2.6 billion budget ceiling. The program was eventually scrapped in 2008, which sent the Navy back to the drawing board for the desperately needed AOR replacement. The "big honking ship" concept followed it to the grave a little over a year later.

The entire episode forced the Navy to realize it had insufficient capacity to actually execute the program despite political support, either within DND to manage the project of this scale or within industry to produce the vessels required. The lack of managerial capacity had contributed to the department promulgating a statement of requirements (SOR) that no bidder could meet as well as asking for the ships to be built for an unrealistically low-cost estimate. This realization would be the genesis of the National Shipbuilding Procurement Strategy (NSPS) and the CSC program.

Canada's shipbuilding industry and the creation of the National Shipbuilding Strategy

The saga of the first iteration of the JSS revealed the second critical dimension that the RCN's Canadian Surface Combatant program had to address – the poor state of the domestic shipbuilding industry. During the first half of the Cold War, the RCN had a robust shipbuilding program that produced successive classes of vessels. However, this ended with the *Iroquois*-class destroyers in 1973, after which there was a long interlude during which no naval ships were built (Milner 1999). In the early 1980s, the government started planning a replacement for the *St. Laurent*-class destroyer escorts and her variants; the *Restigouche, Mackenzie,* and *Annapolis* sub-classes. Despite being largely obsolete, these 20 or so ships represented the vast majority of the RCN's surface fleet. They would be replaced by a single class of warship – the Canadian Patrol Frigate (CPF), which would ultimately become the *Halifax*-class.

In the 1980s and '90s the shipbuilding industry across Canada was also changing. The cessation of direct government subsidies to the civil sector and the increase of foreign competition greatly decreased Canadian manufacturers' competitiveness in the open market. These changes meant that domestic firms were increasingly reliant on government contracts to remain financially sustainable, a significant vulnerability that would become apparent in the coming years (Cairns 2006).

In some ways, the CPF was the last large, complex procurement project that

the government of Canada undertook. It enjoyed strong project management capability: in its heyday, the project had 1200 staff assigned to it, with several hundred members of the design team housed in a single building. As one participant noted, it had real "intellectual heft" that allowed the team to wield significant authority; staff worked collaboratively with the prime contractor. In this case, Saint John Shipbuilding was the prime contractor and was expected to build at least six hulls in the first iteration. However, due to political manoeuvring, the government shifted the building of three of the first six ships to Marine Industry Limited in Lauzon, Quebec (which would later, through a round of consolidation, become Chantier Davie), with Saint John Shipbuilding remaining as the prime contractor (Milner 1999, 287).

Despite this upheaval, the result proved to be an exceptionally capable vessel, perhaps the best surface combatant of its size in the world. At the same time, the government was also undertaking the Tribal Class Update and Modernization Program to upgrade the *Iroquois*-class destroyers to serve as area air defence and command-and-control vessels. Although the project had a reputable prime contractor (Litton Systems Canada) as its lead, it entered receivership during the project, forcing the government to become much more involved in its management.

Part of the issue with the *Iroquois*-class modernization program was the lack of lack of growth margin surrounding the warship; this refers to the amount of space available on a ship to accommodate new weapons, systems, upgrades, etc. By the time TRUMP had started, this class of warship was nearing 25 years of age and had little capacity for upgrades. This resulted in costly technical solutions to problems that arose, such as the reconstruction of the forecastle to incorporate a vertical launch missile system (Milner 1999, 287). The problems that the TRUMP upgrade encountered had an important legacy for the CSC: planners within the Navy were convinced that future developments would need to consider the useable years of life of the vessels. Practically, this meant having excess space and buoyancy within the hull that could be used to incorporate upgrades and new systems as they emerged.

Unfortunately, the successes of the CPF and the TRUMP projects would be short-lived. Although the CPF originally planned for 18 ships, the last six were cancelled as a budget saving measure. The final ship – HMCS *Ottawa* – entered service in 1996. The RCN was also midway through the *Kingston*-class Maritime Coastal Defence Vessel (MCDV) project at the time, with the final vessel of that 12-ship fleet being commissioned in 1999.

The knowledge and experience that had guided the *Halifax*-class, TRUMP and the *Kingston*-class were slowly dissolved as the projects ran down. Other than the *Victoria*-class submarines that were acquired from the UK, which were second-hand *Upholder*-class vessels that had to be upgraded, the federal government had no major naval programs ongoing after the *Halifax*

and *Kingston*-classes. As a result, the acquired knowledge and experience for complex project management dissipated. One participant singled out shipbuilding contracting expertise and the commercial acumen in what was then Public Works and Government Services Canada (now Public Services and Procurement Canada (PSPC)) as an example of the lost knowledge. He further noted:

> I question whether we ever had the ability then or now for complex project management, although it was likely the case in CPF, which I understand was a project with prodigious levels of contingency (much of which was never used) and which was likely an important contributor to that project's success.[10]

These issues were exacerbated by the Chrétien government's Program Review process, which was largely implemented as a cost savings measure (Paquet and Shepherd 1996). The Materiel Group, headed by an Assistant Deputy Minister (ADM (Mat)), saw its staff slashed by over half – dropping from 13,000 to 6000. The cuts were not across the board, either: they fell more heavily on supply and support functions that were important for program implementation. Furthermore, the Program Review halted the creation of large projects within DND, favouring instead using the entire staff of the ADM (Mat) to manage operations, rather than creating specialized project staff that were devoted to a project through its entire life. All of these changes further diminished the government's ability to manage very complex programs, as would become increasingly apparent in the following years.

The government's reduced project management capabilities reinforced broader shifts in the way procurement projects were implemented. The most significant centred around the concept of risk. In the examples highlighted above, the government was able to operate collaboratively with industry and manage risk effectively. However, by the 2000s, the government increasingly preferred to manage risk by pushing as much of it onto industry as possible.

In some ways, this was an acceptable approach considering the nature of Canadian defence procurement. The vast majority of CAF and government acquisitions are for off-the-shelf systems where the risk is relatively low. In these cases, Canada selects an existing system from a contractor that has a history of producing them at scale. While some modification to meet Canadian-specific requirements usually occurs, these are usually fairly minor and tend to have minimal impact on program delivery. Nevertheless, the risks involved in engineering, manufacturing, and developing these systems are significantly reduced by buying off-the-shelf.

The riskiest aspect to this approach emerges when a system requires modifications so it can be adapted for Canadian requirements, as these modifications tend to involve considerably uncertainty, the cost and time for which

are not easily estimated. The inflexibility of the process creates problems. The government issues an RFP with a number of mandatory requirements that are largely established and not alterable to a significant degree. Companies in turn are forced to provide bids that meet these rigid requirements. As a result, they manage the greater risk by pricing it into the program's costs, which often dramatically increases the overall price tag.

The National Shipbuilding Procurement Strategy presented a completely different set of challenges that exacerbated the failings of this approach. In the NSPS case, the government was not purchasing an off-the-shelf capability. Instead, it was funding and managing the reconstruction of an entire naval industry, as well as the ships to be produced by it. As noted earlier, the initial iteration of the Joint Support Ship illustrated this lack of organizational capacity to manage a large-scale project, as well as industry's unfamiliarity and inability to meet the requirements as set out. Thus, in order to proceed, DND – and the government as a whole – needed to develop a better organized and more well-thought-out approach towards managing shipbuilding as a whole.

> *"The government increasingly preferred to manage risk by pushing as much of it onto industry as possible.*

The need to replace the Navy's key vessels and develop the ability to successfully construct them became the guiding principle behind the embryonic NSPS. The strategy's overriding objective was to ensure a sustained Canadian shipbuilding industry that would be capable of avoiding the boom-bust cycle that had exemplified military procurement since the 1960s.

The first major step in the NSPS was to be a competition for what were known as "umbrella agreements." Originally these entailed selecting a shipyard that would produce ships for the government of Canada. The packages were also notational offerings at that time, which meant they did not guaranteed work but rather only expressed general plans for future production. Soon after, the government expanded its concept for the relationship to a search for a "sourcing partner" that would take a much broader role in the production of the vessels for the NSPS. After undertaking due diligence, the sourcing partner would become essentially a prime contractor for the ships they were assigned to produce. The shift in responsibility would include greater concessions from the shipyard that provided the government added leverage over them.[11]

The shift reflected the two trends discussed above – the lack of project management capacity within the government and the preference to shift more risk onto contractors. The change meant that the government would set cost ceilings and deadlines to which the firms would be accountable for. However, as will become apparent later, the decision inserted a new management layer within the project, one with its own interests and profit motives. Considering that the federal government already had a convoluted procurement system with at least a half dozen major stakeholders and lack of clear accountability, this additional layer further complicated the government's ability to deliver on projects.[12]

The umbrella agreements really covered two different sets of contracts. The combat vessels contracts would cover the AOPS and CSC, while the non-combat portion would involve the JSS and Coast Guard ships. The two successful bidders would need to upgrade their facilities to manage and construct the new classes of vessels (Canadian Naval Review 2020).

Ultimately, Irving Shipbuilding in New Brunswick won the combat vessels portion of the contracts (Canada 2012). The firm, the lead contractor for the *Halifax*-class, was the largest and most capable defence shipbuilder in Canada. It was a surprise to some observers, however, that Davie Shipbuilding in Quebec did not receive the non-combat portion of the contract (Berthiaume, Hiltz, and White 2011). It went instead to Seaspan in North Vancouver. In reality, Davie was in receivership at the time it submitted its bid, a fact that only illustrated the yard's tenuous financial position.[13] There was no active work ongoing at Davie, either; the yard had a skeleton crew of just 15 staff (Radio Canada 2011). While DND was assessing the bids, Davie shipyard was acquired by a consortium between SNC Lavalin and the Korean conglomerate Daewoo Shipbuilding. Although this might have improved its chances, the development could not affect Davie's submission. Seaspan, by comparison, was an active yard that Public Works judged to be significantly better prepared meet the government's requirements (Radio Canada 2011).

An unexpected outcome of the RFP process was that both winning yards were willing to invest in their facilities without recourse to government funding. They would instead recoup their investment by amortizing the cost over the ships they produced. Their only requirement was that if no ships were ultimately ordered, the yards would be reimbursed for the upgrades they had made. The government agreed and introduced the backstop agreements that effectively indemnified Irving and Seapsan if such an event occurred. As both yards have since started construction of several ships for the federal government, in the end Canada did not pay for their upgrades.

With the umbrella agreements in place, the program moved to the next phase of the project – developing, engineering, and producing the Canadian Surface Combatant vessels. Since neither the government nor any domestic firm

possessed the technical knowledge or capacity to design the ships, they had to look abroad for assistance in this area. Specifically, they decided to employ a "parent-design" approach. According to the US Congressional Research Service, parent-design is the decision "to use only systems and technologies that already exist or are already being developed for use in other programs, rather than new technologies that need to be developed" (United States, Congressional Research Service 2021a, 20), which can "reduce design time, design cost, and cost, schedule, and technical risk in building the ship" (United States, Congressional Research Service 2021a, 8).

In the case of the CSC, the Navy decided to procure an existing naval design and then modify it to suit its requirements. However, the RCN made the eligibility criterion much more restrictive, requiring the design to be "in service" in order for it to be eligible to be selected, largely as a risk mitigation strategy. The RCN also sought to leverage the AOPS program to build knowledge and experience within the program office and within Irving Shipbuilding before launching the larger and more complex CSC program.[14]

The Navy decided to procure an existing naval design and then modify it to suit its requirements.

Originally, the government had envisioned two separate competitions – one for the warship design and another for system integration. However, by 2017 the government had decided to combine both into a single competition. Thus, industry teams competed to provide both design and systems integration services, operating subordinate to the prime contractor, Irving Shipbuilding. This followed the path set out by similar-sized countries to Canada, which also faced the complexity of modifying an existing design to meet their country's design purposes. This approach streamlined the modification process and avoided adding even more complexity to the project.

The government's role in the process was to provide the general contours of the program. It supplied a broad statement of requirements (SOR) from which the request for proposals was derived. In most procurements, the SOR is fairly well established. However, the CSC program was significantly different. Since this was partly a development program, a substantial part of the design required significant engineering and design work after the winning design was selected to make it viable.

Internally, the government faced a lot of difficulty getting the various stakeholders to agree on the warship's characteristics. Within the RCN and DND

as a whole, one area of debate centred on the overall cost and capability of the warships.[15] As discussed earlier, the CSC program as envisioned in the *Canada First Defence Strategy* had intended there to be two separate classes of warships – the AAW and multi-purpose variants. However, according to the department's internal analyses in 2014, there were very few military advantages to this fleet structure.[16] That finding pushed the department to try to integrate as much capability as possible into a single class of warship.

The problem, however, was that these analyses and debates focused exclusively on military capability, i.e., what would be required for the vessel to operate successfully over its intended lifespan. What the analysis failed to consider was the engineering, manufacturing, and design aspects of the potential project – that building these extremely capable vessels required very high levels of technical expertise in order to integrate widely disparate capabilities.[17] Such complex integration would inevitably drive up the program's cost and introduce delays.

Moreover, the SOR process also encountered challenges from outside the department. As noted earlier, there was the strong impression among some within government that DND had abused the sole-source process for acquiring military capabilities, particularly those for operations in Afghanistan. The perception would help fuel a later controversy; the sole-source acquisition of the F-35 fighter jets in 2010. In addition to cancelling the purchase of the jets, the government greatly curtailed the use of the sole-sourcing within DND, while further institutionalizing the procurement process in order to ensure a fairness in competitions. In many cases, this created process constraints that delayed programs and increased platform costs (Davies 2015).

The constraints also hamstrung DND's ability to employ novel process approaches that could have lowered costs or improved industrial outcomes for the country – whether by restricting competitions to a select group of qualified bidders or sole-sourcing specific systems and mandating their inclusion on the winning bidder's design. Such approaches had the potential to reduce project management complexity and the overall project cost while at the same time ensuring that products from Canadian companies were included in the final design. The latter is a common feature of countries of a size and with constraints similar to Canada, as will be discussed later with regards to government furnished equipment.

On the whole, the various constraints and lack of flexibility reflected the weaknesses inherent within the Canadian government procurement system. Stakeholders such as ADM (Mat), Industry Canada, and Public Works drove the decision-making process, pushing their narrow interests into the process without being clearly accountable or directed by a strong centralized management. The result was decisions that were often suboptimal and even counterproductive. The weak project management leaders were unable to ad-

dress serious problems or had to accept ineffectual compromises to incorporate the various interests and views. Those compromises and poor decisions would become evident in the following years in several areas and resulted in cost escalations, poor industrial outcomes, and overall delays. As a participant in the CSC process stated:

> I believe there are some areas where there could be more flexibility, in terms of tension between the military requirements and industrial and, more significantly, in open and fair procedural requirements. Are we going to specify a certain type of radar or missile system? Or are we going to go with any supplier and are prepared to ignore the implications of global supply chain and become one of the only users of a boutique set of capabilities? A lot of this we were constrained, we wanted US technologies. However, because the perception was that was going to undermine certain suppliers' competitive ability, we were unable to go down that road. That's an area that we're going to need some discussions. We tend to look at the decision on a project in isolation to the other things going on. It looks at a very focused lens of industrial benefits, bid compliance, costs, in opposition to other significant considerations.[18]

Another area of major consideration is the CSC program's intellectual property (IP) rights. If the government was able to secure the IP rights to the design and technology in the ships, this would enable Canadian shipyards to produce the warships and export them. More importantly however, owning IP would make it easier for the government to modify and maintain the platform. This would provide the military with greater freedom to make design changes to suit their requirements, and even to inject competition into these programs, which would help drive down the project's overall cost. Owning the IP has its advantages, but also comes with drawbacks. Generally, if Canada owns the IP, it also means Canada will be the only user of that particular system and therefore will be responsible for maintaining its combat relevance. Canada cannot rely on upgrades or co-development schemes with other users to allay the costs. As a rule, however, the federal government prefers to obtain as much IP as possible as, on balance, it offers several major advantages (Canada, Public Services and Procurement 2021).

However, the most serious concern is the cost of obtaining IP in the first place. If the capability it provides is current or cutting edge, its costs are likely to be exorbitant, if available at all. A firm (or government) that paid for a system's development would want to recoup its investment and the future profits it would no longer receive once Canada owned the IP. Furthermore, in many cases IP cannot be sold because national export control regimes prevent it from being released to foreign states due to security concerns.

The IP became a serious issue for the CSC program. The government had initially asked for all of the IP, including the programming code. Potential competitors immediately rejected the request for the reasons discussed above (Brewster 2016a). This episode illustrates the government's inexperience and lack of project management capability – the request was one that no competitor would realistically fulfill.

We do not know what, if any, IP that participants offered as part their bids. Most bids likely offered the government a licence for the production of the system along with permission to modify the design to meet Canada's requirements. However, one potential competitor had a slight advantage. In the 1990s, the government had started to domestically develop a combat information and command management system for its *Halifax*-class frigates. The original prime contractors for this system, known as CCS330, were Lockheed Martin Canada and Saab (though the latter would later exit the program). The system used design elements from the Aegis combat system, which was the US Navy's premier shipboard combat management system, but without any of the components related to its radar system.

The CCS330 system was developed within Canada, so it is not subject to the same export controls as systems developed outside the country. Crucially, the government also owns CCS330's IP. As a result, they would likely demand the system to be installed on the eventually selected design for the CSC. This situation provided Lockheed Martin with an advantage – by offering fairly precise cost and capability estimates for installing the system and, by using government IP, it conferred obvious advantages and enhanced the attractiveness of their submission.

The CCS330 experience is a good example of a situation where the government should have insisted that bidders include a Canadian-designed combat management system as government furnished equipment (GFE). Indeed it was an area of discussion among senior officials.[19] Basically, requiring a Canadian-designed combat management system would have created a level playing field among the competitors, ensuring that a major piece of Canadian IP would be sustained for the foreseeable future and all of the industrial benefits would accrue from this approach. Other countries employ this approach. The Australian government, for example, mandated that its domestically produced SEAFAR radar system be installed on their upcoming frigates, no matter which bidder won the competition to build them (Pittaway 2019). The US Congress, for its part, essentially mandated that a number of subsystems on their next generation frigate program (FFG(X)) be replaced with domestically sourced systems (Consolidated Appropriations Act, 132, 133).

This issue was not just limited to the combat management system. RCN officials pushed for greater commonality in two other major areas: the bridge and integrated platform management systems. Both are products for which

there were able Canadian designers that were world leaders in their respective applications.[20] Commonality has a number of practical benefits for the Navy. By deploying one system across multiple classes of vessels, Canada could significantly reduce the amount of training needed to crew these ships, thereby reducing operational risk and overall cost for the RCN, reducing logistical challenges, and boosting Canadian industry.

As discussed above, however, the PSPC did not generally favour using GFEs for specific systems, despite its obvious advantages. Simply put, GFEs were seen as contrary to their objective of ensuring that the procurement process was open and fair. By limiting the use of GFEs, the PSPC meant to avoid giving any hint of favouritism to a specific platform in the competition. However, as we will see, it was another in a string of decisions that would hamstring the government's ability to execute key aspects of the project.

> *Firms that had lost … now believed they could successfully challenge procurement decisions outside of the process.*

During this time one final problem emerged concerning acquisitions, but it did not involve shipbuilding. In the early 2000s, the RCAF required a fixed-wing search and rescue (FWSAR) aircraft to replace its venerable CC-114 Buffalo. At the time, the Air Force had undertaken a detailed and lengthy analysis of its needs and assessed the available options and realized only one aircraft could meet its requirements – the Alenia (now Leonardo) C-27J. The C-27J was fast and had a long-range, enabling it to reach all of Canada's areas of search and rescue responsibility within one flight crew day. It also had plenty of power and excellent vision around the cockpit, which would enable it to operate effectively in the tight confines of Rocky Mountain canyons.

On this basis, the RCAF decided to undertake a sole-sourced procurement of the C-27J. No other aircraft could meet several of the specifications and sole-sourcing had the ancillary advantage of avoiding a drawn-out procurement process. It would also allow the federal government to enter into a process in which they could negotiate a profit margin for the contract with Alenia. The government prepared what was known as an Advanced Contract Award Notice (ACAN). This formally signals their intent to award a sole-source contract to a supplier unless a rival company can demonstrate that they can meet the requirements set out. Before the ACAN was issued, one of the man-

ufacturers that was going to be excluded from the procurement lobbied the government heavily to stop the process.[21] Their product could not meet the range, power, or visibility requirements that the RCAF sought, which meant they could not challenge the ACAN itself. Nevertheless, their lobbying efforts were successful and the ACAN was scrapped a week before it was to be issued. It led the entire FWSAR program to be shelved for another seven years.

Many in the government viewed the entire FWSAR episode as a turning point in Canadian military procurement. Firms that had lost (or were going to lose) now believed they could successfully challenge procurement decisions outside of the process. This took several forms, including lobbying, both directly to officials and indirectly through the press, as well as court challenges. As one senior Air Force official involved with the FWSAR said, it became "open season on procurement" after it was successfully challenged.[22]

Whether FWSAR was truly a precedent can be debated, but it certainly was a harbinger for the way future challenges would be handled. One example was the 2007 decision to award the *Victoria*-class submarine maintenance contract to a consortium led by Babcock based in Victoria, BC. Irving Shipbuilding had anticipated it would be a subcontractor in a broader bid by BAE, which would undertake all the RCN's in-service support. However, upon losing the competition, Irving filed suit in federal court to get the decision overturned (CBC 2007). It also undertook a private[23] and public lobbying campaign to force the government into cancelling the tender, citing better job outcomes in specific areas. Manufacturers that had been passed over for other programs, such as the replacement of the F-35 fighter jets, which was also a sole-source selection, engaged in similar lobbying efforts. This same situation would emerge during the CSC program.

The CSC Competition

Twelve groups participated in the early CSC information sessions that the government organized and four bids were anticipated. The first was led by Alion Canada and incorporated the Dutch Damen Group for the latter's *De Zeven Provinciën*-class frigate. This class of ship was originally de-signed as an air warfare ship, but it also possessed a unique anti-ballistic missile capability and modest anti-submarine capabilities.

The second was the Spanish F-105 design, based on the final ship of the *Álvaro de Bazán*-class, which was offered by a consortium led by Navantia, the vessel's manufacturer. Like the *De Zeven Provinciën*-class, the F-105 was primarily an air warfare destroyer. Navantia has been reasonably successful at producing its ships for foreign buyers, including the Royal Australian Navy (RAN), which is currently constructing its *Hobart*-class destroyers based on

the design. Importantly, both of the Alion Canada and Navantia bids had one aspect in common – their designs were developed in the late 1990s and early 2000s and reflected the expected challenges of that period. As a result, the ships' designs are almost two decades old.

The next potential competitor was a consortium led by Lockheed Martin, which teamed up with BAE Systems to offer the latter's Global Combat Ship. Unlike the other options, no ships of this class exist – the lead ship of eight will be the British Royal Navy's Type 26 Frigate, was expected to enter service in the next decade. The Royal Australian Navy also selected the Global Combat Ship design for its next class of nine multi-purpose frigates. This history was a double-edge sword, however. It was by far the most modern design on offer and would easily meet many of the future scenarios DND envisaged. At the same time, it was not a design already in service, which had the potential to disqualify it from the Canadian competition.

Then ADM (Mat) Pat Finn later provided clarity when he stated that the Global Combat Ship would be allowed to compete, in part due to the reality that all competitors would need to make significant modifications in order to make their ships useful for Canadian service (Brewster 2016b). This statement elicited significant protest from the other competitors, who claimed the program was giving the BAE-LM team an unfair advantage (Brewster 2018).

The final contender was the Franco-Italian FREMM multipurpose frigate, proposed by Fincantieri-Naval Group consortium. Some saw it as the front-runner in the competition. The FREMM is a highly versatile warship. The first vessel entered into service in 2012 and a number of different variants are in operation. Moreover, the consortium has extensive experience collaborating with other governments and is the largest builder of European surface combatants, which could help to drive down program costs (Bray 2012). In April 2020 a derivative design of the FREMM won the FFG(X) competition in the United States. Known as the *Constellation*-class, its modifications would include significant structural reinforcement and a completely new electronics, sensor, and weapons fit.

Despite all of its advantages, FREMM had an early, and perhaps one of the most dramatic, exits from a Canadian procurement program in recent memory. On December 1, 2017, the day after bids were to be submitted, a story appeared in Postmedia papers that featured an exclusive interview with representatives from Fincantieri-Naval Group (Pugliese 2017). The reporter announced that Fincantieri did not submit a bid, but offered a fixed-price agreement to build the vessels outside of the NSPS (now renamed National Shipbuilding Strategy or NSS) structure. The fixed price was $30 billion for 15 vessels, but the representatives offered few other details, including for the associated project and lifecycle costs.

The story claimed that "[d]efence industry insiders" believed the consortium might have "nothing to lose by trying to circumvent the CSC procurement process, which a number of observers believe is skewed to favour a bid by Lockheed Martin Canada and the British firm BAE." However, another possible reason that Fincantieri did not submit a proposal is that the French government has been generally reluctant to operate in the type of licensed work arrangement that the NSPS favours. This became evident in India's purchase of 126 Rafale fighters – a deal that collapsed over arrangements for domestic production of the aircraft (Samanta and Pubby 2018; Mint 2014). Similar problems were also apparent with the Australian Navy's now-cancelled *Attack*-class submarine procurement (Pittaway 2020).

> *The likely true cost of the FREMM was not dissimilar to the BAE-LM Global Combat Ship design.*

Details released to Postmedia of other aspects of the offer also signalled trouble. Of the 15 vessels, the first three were to be produced in Europe, after which the remaining 12 were to be manufactured under licence in Canada by Irving. This entailed an inversion of the NSS structure – the consortium would become the prime contractor and Irving's role would be simply to implement the decision. There were also problems in Fincantieri-Naval Group's proposed handling of IP and sub-contractors. The article suggested there would be a limited form of tech transfer that would allow Canadian firms to compete in some international competitions. This likely meant that FREMM would incorporate some Canadian components and transfer IP in some areas, but those changes would then be offered on all ships of the class produced internationally (Pugliese 2017).

At the same time, it is highly likely that a very large proportion of the RCN's FREMMs would be produced abroad and then assembled by Irving in Canada, which was contrary to the original intent of the NSS. Furthermore, the Fincantieri-Naval Group's proposal was unlikely to produce significant savings. A Parliamentary Budget Office (PBO) estimate suggested the cost savings only amounted to 10 percent the cost of the existing CSC program, extrapolating from early estimates of US's *Constellation*-class (PBO 2021a). Even this saving was likely unachievable for Canada considering the US Department of Defense has much deeper experience managing naval shipbuilding contracts and the ability to access existing American or European suppliers without any roadblocks such as the International Trade in Arms Regulations.

As a result, the likely true cost of the FREMM was not dissimilar to the BAE-LM

Global Combat Ship design. The government rejected the FREMM proposal four days of it being announced, stating "The submission of an unsolicited proposal at the final hour undermines the fair and competitive nature of this procurement suggesting a sole source contracting arrangement" (Canada, Public Services and Procurement Canada 2017). The news release went on to point out "that suggestions significant savings could be realized through this alternative process, this is far from evident" – which undermined the consortium's primary argument.

With the FREMM out of the running, NSS evaluated the three remaining competitors and their bids for the CSC program: Alion Canada's *De Zeven Provinciën*-class, Navantia's F-105, and BAE and Lockheed Martin's Global Combat Ship. The statement of requirements has never been publicly posted, but there are aspects of it that can be gleaned from the information that was released into the public domain.

As with other major competitions such as the Future Fighter capability project, the RFP for the CSC project asked bidders to detail how their offering would address specific scenarios outlined in the document (McColl 2020). Their responses would be scored in a pairwise fashion and included in their overall evaluation. While not explicitly stated as such, it was in these scenarios that many of the key requirements for interoperability manifested themselves. For instance, it is highly unlikely Canadian warships will ever operate in a very high intensity combat situation unilaterally, particularly without American support. Thus, to obtain a high score in the competition, Canada's warships must have sensors and weapon systems that can seamlessly integrate with those of US task forces, particularly with the Naval Integrated Fire Control-Counter Air (NIFC-CA) system. This system enables a vessel to transmit sensor and weapons data between similarly equipped platforms, vastly increasing its effectiveness.

It was also clearly important for the design to be adaptable enough for the ship to remain operationally relevant late into its service life. Crucial in this regard was to ensure sufficient growth margin area for new systems and upgrades, a need that was emphasized by the painful experience of the TRUMP upgrades for the RCN's destroyers.

This entailed other considerations, significantly for power generation and electrical systems. Like the US Navy's vessels, Canada's warships tend to operate far from the country's coasts and in deep water, which rrequires reliable power plants, expanded food and parts stowage, and a large fuel capacity. Other factors include advanced sensor, communication, and data processing systems that require increasingly more power to operate. Furthermore, the advent of energy weapons like the US Navy's HELIOS (High Energy Laser with Integrated Optical-dazzler and Surveillance) system, which is starting to see service on *Arleigh Burke*-class destroyers, has the potential to vastly increase

the power requirements of new vessels.

Future-proofing extends to other aspects of the vessel design as well. Adding new systems literally affects a warship's balance. Sensors and electronic warfare systems must be mounted as high as possible to increase their effectiveness, while the electronics that will run them will likely increase in size as well. Weight high on the ship reduces the stability of the vessel, so the weight of the initial design must be distributed and balanced against projected future weight growth. Once the extra design weight margin has been used up, future additions must be matched by corresponding removals lest the ship risk capsizing under rough seas or battle damage. Other considerations include increasing berthing and social space sizes for crews, and allowing for greater habitability over earlier design types.[24]

> *"It is highly unlikely Canadian warships will ever operate in a very high intensity combat situation unilaterally.*

Given these factors, the BAE-LM Global Combat Ship had a definite advantage over its competitors. The ship was not only physically larger than the other two competitors, but it was also two decades newer and incorporated many of the above-mentioned considerations into its design. For example, it combined diesel-electric or gas (CODLOG) system, that ensured the ship would have significant reserve power capacity for future design needs (Navy Lookout 2019). As a result, the powerful diesel power units normally dedicated solely for propulsion could also be used for shipboard power generation. In the other two designs, the power units drove the shaft directly, while another set of generators supplied the ship with power. The Type 26 frigates had 12MW of potential shipboard power, compared to the approximately 7MW for the *De Zeven Provinciën*-class and 5MW for the *Hobart*-class/F-105 (Navy Lookout 2019). The power not needed for propulsion could be used to power larger radar or electronic systems, a key consideration for a combat vessel with AAW responsibilities.

Compared to design adaptability, design cost was given relatively low priority. As part of the parent-design approach, the Canadian Surface Combatant's RFP was asking for a reference design, not a finished one. Since significant portions of the winning design would eventually be modified in ways that were not clear at the time of the competition, the bidders' cost estimates would be inherently and necessarily unreliable.[25] Thus, the adaptability of the design and its ability to meet the government's requirements were given a significantly heavier weight than the cost.

Post-selection challenges

On October 8, 2018, the BAE-LM team was selected as the winner. While this was a major milestone, there was a significant amount of design work and negotiations still to be done under the Requirements Reconciliation phase. Complex competitions such as this are not necessarily finished deals, but rather are the first opportunity for the chosen supplier to sign a contract with the government. Additional negotiations and analysis are needed before the RFP can be turned into a final contract. If the parties fail to reach an agreement, then the government may turn to the second or third preferred bidder and start negotiations with them. However, such an outcome is exceedingly rare as most winners of the RFP eventually do sign their contracts. This was the case with the CSC. BAE-LM signed a $185 million design contract with the government on February 8, 2019, which ended the Requirement Reconciliation phase (Canada, Public Services and Procurement 2019).

Even with the signing of a design contract, the government did not have a ready-to-build design. Rather, what the RFP required was a largely incomplete framework, which needed significant development and refinement to produce a mature design. This period, known as the Design Development phase, is when DND and the prime contractor negotiate various features of the design. It is here where the CSC's unique structure comes into play. The revised umbrella agreement made Irving the prime contractor, so Irving was responsible for negotiating with the BAE-LM team on the design. As noted earlier, this added level of management likely contributed to one of the CSC's more intractable issues in the public's view: escalating cost estimates.

When the BAE-LM team was originally chosen for the task in 2018, the program was envisioned to cost between $56 to $60 billion for 15 warships (Canada, Public Services and Procurement 2019). This itself was a significant increase from the projected cost five years earlier, which was pegged at around $26.2 billion (Auditor General of Canada 2013a). After the contract was awarded, the estimate continued to increase unabated. While DND's official statements stood by the $60 billion assessment, several other groups have suggested that the number will be much higher (Canada, De-partment of National Defence 2021a). Key among this group is the PBO, which has steadily increased their independent cost estimate for the program from $69 billion in 2019 for 15 vessels to $77 billion in 2021 (PBO 2019, 2021b). The escalating numbers created significant controversy among the public (Pugliese 2020a).

The CSC's challenge is that acquisition costs are difficult to estimate, even at this stage of the program's maturity – this was evident in the RFP where the cost elements were not weighted as heavily as other areas, as noted earlier. Moreover, the PBO's estimates are heavily based on parametric formulas, which a Defence Research and Development Canada (DRDC) paper explained as:

> Parametric approaches to cost estimation use regression or other statistical methods to de-velop Cost Estimating Relationships. A strength of parametric approaches is their potential to capture major portions of an estimate quickly and with limited information. A major dis-advantage of high-level (top-down) parametric approaches is that they do not provide low level visibility (cost breakdown), and changes in sub-systems are not reflected in the estimate if they are not quantified via an independent variable. (Canada, Defence Research and Development Canada, 2011)

PBO frequently employs this approach, which has been a source of controversy. For example, in 2011, it employed parametric estimates to analyze the potential cost of Canada acquiring the F-35 fighter jet in 2016 up until 2022 (Yalkin and Weltman 2011). The PBO estimates suggested an average cost that was approximately double what the actual cost would have been had the purchase gone through.[26] The PBO's reports on the CSC use a similar parametric approach, including using weight as a key independent variable to assess the potential cost increase. The DRDC report in this area is instructive:

> It is widely accepted that top-down parametric models for cost estimation are more suitable during the design and early development phase of a program. As the program matures, entering the implementation phase and beginning initial production, bottom-up engineering approaches are more suitable as they incorporate known costs and more accurate uncertainty intervals. (Canada, Defence Research and Development Canada, 2011)

In its 2021 report, the PBO increased its cost estimates for the CSC procurement program by 11 percent since its 2019 assessment, which it attributed to a roughly similar increase in the ship's projected weight (PBO 2021a, 18). However, the report noted that access to more accurate costing has allowed it to refine its estimates downwards, which is consistent with the approach suggested by DRDC. It illustrates the inherent uncertainties surrounding the cost estimates of the CSC program.

This is not to suggest that cost escalation is not a possibility – it is likely unavoidable at this stage. Production delays have exposed the program to inflationary pressures that will erode the purchasing power of its original estimates. Rather, the question should be what the scale of the increase is relative to the earlier cost estimates provided by DND, and the public perception of those increases. Considering the public's lack of understanding of the program's details, any increase in the estimate will reinforce existing narratives about CSC's mismanagement.

Nevertheless, the potential for cost escalation has led DND to institute several policies. One of the more obvious was the ADM (Mat) deciding to freeze the

design except for all but a small number of essential changes.[27] This would avoid engineering design changes during this period, which would likely increase costs and possibly create delays for the program. A design freeze is a common and often an effective approach to curtailing costs, but it comes with trade-offs, including potentially closing off possibilities where DND could reduce the long-term cost of the vessels. In some ways, implementing the policy was a tacit acknowledgement of the government's limited ability to manage risk, as outlined earlier by the Office of the Auditor General (Auditor General of Canada 2013b).

> *Any increase in the estimate will reinforce existing narratives about CSC's mismanagement.*

One example of this was the Close-in Weapons System (CIWS). All modern surface combatants have a layered approach to air defence and have different systems for different ranges. The CSC has three – a long-range system around the Raytheon SM-2 missile, a medium-range system using Raytheon's Enhanced Sea Sparrow Missile (ESSM), and a close-in system designed as a last-ditch effort to stop incoming missiles. The BAE-LM team originally bid on the CSC using the MBDA SeaCeptor as its close-in defence weapon, but it was generally expected that this system would be dropped for the Raytheon Rolling Airframe Missile (RAM). This was a widely used system internationally, with the added benefit that the RCN could reuse components from the *Halifax*-class frigates to decrease costs.

This expectation was evident some of the marketing materials the BAE-LM team created prior to their selection, which prominently highlighted the RAM system on the vessel (Vavasseur 2019). However, DND's diktat to refuse any modifications resulted in the plan to use the RAM being scrapped and the retention of the SeaCeptor missile system as originally included in the baseline Global Combat Ship design. This decision might save some money in the manufacturing and production of the ships, but will cost more once the ships are in service due to the price tag for the individual missiles.

The program's management shortcomings extended to suboptimal industrial outcomes as well. In the fall of 2020, news reports emerged that several major Canadian naval producers were unhappy at not being asked to supply components for the CSC program (Pugliese 2020b). This has been a long-term concern for these firms; many are considered world class in their respective fields, but they have been shut out from the program since its inception.

It was not necessarily the government's intention to shut these producers out, but rather an unintended consequence of the industry team approach and changes to how the government pursues industrial benefits. In 2014, the federal government implemented the Defence Procurement Strategy (DPS). This altered key aspects of Canada's industrial regional benefits (IRB) program, which sought to ensure that Canada would receive a domestic economic windfall for any defence procurement sourced from a foreign vendor. These benefits, commonly known as offsets, are reciprocal contracts or investments that a winning foreign firm makes in Canadian industry. In Canada these offsets are mandatory for any contract above $100 million, and the reciprocal offsets must equal the total value of the original purchase (Canada 2018a).

Prior to 2014, IRBs were a simple pass/fail requirement: so long as a manufacturer met them, it would not affect the evaluation of their bid. Furthermore, only a portion of the reciprocal benefits needed to be identified at the time of the competition, with the rest to be identified and delivered over the lifetime of the contract. At the time, the outcomes were seen as insufficient and easily circumvented (Aerospace Review 2012) – a common refrain then was that the IRB delivered garbage can lids for Canada.[28]

The 2014 DPS changed key aspects of how this country pursues offsets under what is now called the industrial and technological benefits (ITBs) program. The most critical change was that the quality and volume of offsets could now be part of the program's evaluation criteria, but only up to 25 percent. Yet if other criteria areas were relatively easy for all competitors to meet, such as cost or performance, then the ITBs could easily have a greater role in determining a winner than the 25 percent benchmark suggests. The DPS also improved the IRB's evaluation criteria, so they could be used to improve this system, as well as be more effective at delivering specific outcomes. This was known as the Value Proposition (VP) – where the offset offered by the program would be evaluated against a series of objectives set out by the government of Canada specific to the procurement project.

However, it should be noted that no large procurement programs ever had 100 percent of the dollar amount returned in reciprocal contracts; this would be wholly impractical as no foreign company could be reasonably expected to reinvest an amount equal to the value of the project they were bidding on. Instead, the government incorporates a concept called "multipliers." This means that investment in areas known as Key Industrial Capabilities (KICs) are "multiplied" as much as six times when counting towards a program's ITB requirement. These KICs are priorities within Canadian industry that are generally related to the program's environment. For the 2015 medium-range radar program, for example, its KICs revolved around electro-optical, radar, sonar, fire control, warning, countermeasures, electronics, information technology (including software), communications and navigation systems and components (Canada, Public Services and Procurement 2018). The CSC was similar, prioritizing investments in the naval sector.

The industry teams approach has helped bidders offer a better value proposition for their bids by incorporating subcontractors who could add to the offset contribution. The irony here is that the ITB policy disadvantaged some Canadian firms, which cannot provide more than 100 percent value. Certain competing foreign subcontractors could offer offsets that are as high as 600 percent of their potential contracts through the use of multipliers. This has meant they are more valuable to the industry teams than Canadian firms. Only a few firms can take advantage of this opportunity, though – largely ones that have had some sort of pre-existing footprint in Canada.[29] Moreover, the government curtailed the opportunity for bidders to fully exploiting this loophole by reducing the potential multiplier benefit to the program.[30] Still, a few foreign firms were retained in this fashion. This was suboptimal even by stated government policy, which ostensibly prioritizes direct work by Canadian firms (Canada 2018b).

> *"No large procurement programs ever had 100 percent of the dollar amount returned in reciprocal contracts.*

Potential domestic subcontractors also faced the difficult choice of picking the right industry team that would win the competition. Those that had not partnered with the winning bidder, either because they chose a different competitor or sat out the process, faced significant risk. The winning bidder may have already had in place a designated supplier for their component (which meant the domestic subcontractor had virtually no chance to win) or entered the competition themselves to become the supplier for their own system. This required Canadian firms to market themselves effectively – often playing up not just the cost and performance of their systems, but the potential value of their inclusion within the ITB-VP format. Ultimately, several Canadian firms, with critical expertise in relevant fields, such as DRS Technologies, were shut out from the program (Pugliese 2020b).

All that said, the potential for a contractor to be awarded a part of the job post-contract selection became even less likely due to the design freeze instituted to control costs. Normally it was highly likely that several of the systems to be used in the vessels would have been retrofitted after the contract selection, as was the case with the SeaCeptor/RAM situation. Yet DND's design freeze limited that chance. Moreover, the government itself could have mandated these systems be incorporated by making them GFEs. However, as discussed earlier, the government viewed this approach as prejudicial and against the fair competition process and thus it was not adopted even though it would have helped meet some of the government's own industrial development objectives.

In addition to the challenges faced by the program, it was also the target of significant criticism and public pressure brought to bear by industry. As with the FWSAR episode discussed earlier, firms that had lost out in the bidding process had a significant incentive to try to overturn the results by whatever means they saw appropriate.

Both Alion and Navantia formally protested the bidding process after the BAE-LM team was announced the winner. Initially, they approached the Canadian International Trade Tribunal, which dismissed their case in late January 2019 (Brewster 2019). Alion also filed suit in Federal Court, but no decision has been rendered at the time of this publication. Other firms criticized the program in public while also lobbying the government behind closed doors.

However, these efforts have paled in comparison to the conflict over the CSC's primary air defence radar, a critical aspect of the ship's design. The original Type 26 design used the Type 997 Artisan Radar, a relatively low-cost, medium-range system installed on several frigates and other vessels. The Royal Navy installed the Type 997 Artisan Radar, a less capable system, because it already possessed six *Daring*-class air defence destroyers, dedicated air warfare vessels with their own powerful radar array.

As noted earlier, the initial CSC concept was to commission three specialized AAW destroyers that were to complement 12 multi-purpose warships. However, by 2016 this concept had been scrapped in favour of consolidating all the ships under one design. This decision meant that all the CSC ships would require a highly capable radar system to undertake air defence, which would be complemented by a suite of surface-to-air missiles. To accommodate these changes, the Global Combat Ship design was extended by two metres and about a thousand more tons was added to the ship's unloaded weight (Naval Technology Undated). For its bid, the BAE-LM team elected to use its own SPY-7 Radar system, but its acceptance was not a foregone conclusion.

The SPY-7 was a part of a new generation of shipborne Active Electronically Scanned Array (AESA) Radars, with transmit and receive modules that used Gallium Nitride (GaN) technology that greatly increased their range, sensitivity, and flexibility. There were several other potential systems the design team could choose among, the most likely being the Raytheon SPY-6. Originally Raytheon was part of the BAE-LM team working on the CSC proposal, though they parted ways very early in the bidding stage. Furthermore, the competition restricted bidders outside of NATO or Australia/New Zealand, which prevented some firms from competing, such as Israeli firms. Given the critical importance of the system to the ship's operation and design, the BAE-LM team selected the SPY-7 radar as part of the bid they submitted to the Canadian government. This was opposed to leaving the choice up to a secondary competition if they were picked to supply the CSC design.

The histories of the SPY-6 and SPY-7 radars are intertwined beyond the CSC program. The Raytheon SPY-6 won the original US Navy competition to replace the 1980s-era SPY-1 system and will be installed on most future US Navy's surface combatants, such as later versions of the *Arleigh Burke*-class destroyer and the *Constellation*-class frigates (Naval News 2021). After losing out to Raytheon, Lockheed Martin's SPY-7 won the Missile Defense Agency's competition for a series of land-based, ballistic missile defence radars (Judson 2021). It has since been selected for the Spanish F-110 class of frigates and will be installed on a new class of Japanese anti-ballistic missile destroyers (Inaba 2020). In short, both are highly capable naval radars that are roughly equivalent in their capability, though the SPY-7 showed more advanced development in shipborne integration.

> *All the CSC ships would require a highly capable radar system to undertake air defence.*

The selection of the BAE-LM bid in early 2019 led to Raytheon lobbying intensely to undermine the SPY-7's inclusion, despite the fact it was not part of the submitted GCS design. Raytheon met with government officials nearly as many times in one year as in the previous four years combined.[31] Raytheon also created a briefing deck that highlighted the perceived shortcomings of the SPY-7 radar versus their SPY-6 radar. Furthermore, they communicated that information in a letter to the Clerk of the Privy Council that outlined many of these concerns. The letter was reportedly poorly received within government. It led the Deputy Minister of National Defence, Jody Thomas, to issue a rare rebuke to companies engaging in highly political lobbying efforts (Pugliese 2021). In the end, the SPY-7 remains the radar system selected for CSC program, but the reporting and lobbying about it have contributed to negative public perceptions of the project.

Despite all these challenges, the CSC continues on. At the time of this publication, the CSC project is nearing its preliminary design review phase, which should commence by the end of 2021. This phase marks the point where most of the key aspects of the design will have been finalized, which will allow for review and system integration. By 2023 the design and production process develop-ment should be completed, at which time the RCN should be able to start cutting steel on the first vessel. To that end, it will start the production of an initial test manufacturing module, with the official start of the first vessel expected to commence a year later in 2024. The launch of the first vessel is planned for 2029 with an initial operating capability in 2031 (Brewster 2021). Afterwards, the RCN will receive one new vessel roughly every year until 2045, at which time the program will end.

Conclusion

The CSC program is arguably the most challenging and complex procurement project ever undertaken by the government of Canada since the 1960s and the Avro Arrow interceptor program. The estimated costs of the program and its slipping delivery date have become cause for concern. Given the essential mission that the CSC will undertake, commentators and observers have made well-meaning suggestions in the hope of correcting the CSC's failings. They include re-competing the design award, purchasing a less capable class of warship to complement a truncated purchase of the Global Combat Ship, or simply just settling for the purchase of fewer of them.

Unfortunately, none of these ideas are likely to decrease the cost of the ships to Canada in any meaningful way. Instead, implementing any of them would almost certainly lead to significant capability deficits. Canada would still need to build the vessels domestically, meaning that the cost of the vessels would likely be high even if we opt for less capable warships. For example, if the government abandoned the Global Combat Ship and selected a different design (like the *De Zeven Pro-vinciën*-class or F-105 designs) or purchased a complementary class of less capable warships (like the Royal Navy Type-31), it would need to invest heavily to transform that design into a ship that would meet the needs of Canada's Navy. These changes would need to go through the Requirement Reconciliation, Preliminary Design Review, and Final Design phases. Furthermore, the government would likely insist on making significant requirement changes, installing systems like CCS330 and the integrated bridge and power plant management systems that are common to other vessels in the RCN fleet. These have major long-term advantages for cost and training of personnel but necessitate significant modifications to incorporate – which would all add to the cost of the ships.

Moreover, given Canada's preference for offloading risk and allowing for-profit firms to be primarily responsible for program management, any changes to the design, technology, or production of the vessels would almost assure significant cost overruns and delayed timetables. While the government's ability to manage a program of this complexity may have improved since the first iteration of the CSC program, starting anew with a different design would still take a decade to implement. It is almost certain that no cost savings would be had, especially when considering the cost of running an entirely new competition, and then undertaking the requirements reconciliation process all over again. It would also force Canada to operate two types of vessels, reducing the potential economies of scale that would be realized with a single class of warship. Finally, the delay in obtaining replacements for the *Halifax*-class would require costly life-extension refits to those vessels and subsequent higher operating costs. All of these factors would erode any potential cost savings that might initially make some of the alternative ideas appear attractive, while also delaying the badly needed modernization of the Navy.

Another frequently offered option is to curtail the number of ships Canada will purchase for CSC. This will cut the upfront capital costs, but not as much as some would suggest. Learning-curve effects mean that as Irving produces more vessels, it will become more proficient at doing so, which will create a cost saving per ship. Applying a learning curve formula suggest that the final vessels produced out of the 15 should cost somewhere between 28 percent and 40 percent of the first vessel produced. Lowering the number of ships would also mean that long-term costs savings are unlikely to be realized because fewer hulls will have to shoulder the same burden of responsibilities; this will result in the ships aging more quickly and at a higher cost. Furthermore, reducing the number of ships will undermine the other primary objective of the NSS program – to build a sustainable shipbuilding industry in Canada. A break in construction for more than a few years between the CSC and its eventual replacements would mean the loss of decades of effort and billions in investments made to establish the NSS. Ironically, it would be history repeating itself with the break between the *Halifax*-class and the CSC – an outcome that should be avoided at all costs.

> *A break in construction for more than a few years ... would mean the loss of decades of effort.*

One possible way to cut costs would be to modify several vessels in the class to a lower specification, perhaps by removing sensor systems and/or other equipment. There is some historical precedence for this. In the 1970s, the US Navy produced the *Spruance*-class destroyer, a relatively austere design that was highly focused on its primary anti-submarine warfare mission. In the late 1970s, the *Spruance* hull design and machinery configuration was adapted for a new class of anti-air warfare warship, the *Ticonderoga*-class cruiser (United States, Congressional Budget Office 2020). Incorporating the SPY-1 Aegis radar system, the cruisers were far more capable at air and surface warfare than the *Spruances*, but this came at roughly double the cost for each hull. Canada could attempt the reverse process, initially purchasing a number of highly capable versions based on the current design envisaged, then redesign the warship using the same hull, propulsion, and combat management system, but with less capable sensor systems or weapon load-outs. However, this approach is also fraught with challenges and would likely result in significantly poorer outcomes all around. It would constrain the RCN's flexibility and still incur significant development costs that may not be allayed by the less capable design's lower capital and operating costs. More research would need to be done to validate this proposition.

Barring one of these radical shifts, which in any case are unlikely to deliver a similar level of capability and/or dramatically reduce cost, the present form of the CSC program will remain. Nevertheless, the experience with the CSC has lessons for other defence programs.

DND has recently launched a program to replace the *Victoria*-class submarines. The replacements will need to come online some time before 2040. As Jeffrey Collins identified in a recent MLI paper, Canada has three options if it decides to invest in updating its submarine force:

- It can build them domestically
- It can find an overseas producer to make the vessels based on a Canadianized foreign design
- It can build the submarines collaboratively with an allied nation (Collins 2021).

Many of the imperatives that guided the CSC program are relevant for this discussion.

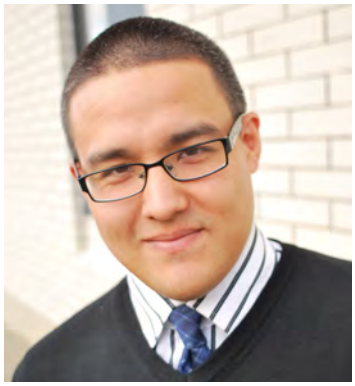
As Collins notes, Canada has no real domestic submarine-building knowledge. The unique and technically complex nature of producing these craft is much less developed in Canada than is traditional shipbuilding and the CSC. Producing them in Canada would likely require additional upfront investment by the government, which makes it unlikely that the government would choose to build them in this country.

Additionally, as was evident with the CSC's development, any approach the government chooses will involve many modifications to the selected design to meet Canadian requirements. In particular, the submarines must be interoperable with US forces. This was the case with the *Victoria*-class submarines, which were extensively modified: many of the British components were removed and replaced with US Navy-compatible ones. The CSC was no different. The reference-hull design approach and the RFP that emphasized interoperability meant that much of the development and engineering work that was undertaken focused on incorporating weapon, sensor, and electronic systems, which tend to be the costliest portion of any combat system design. This may push the government to accept the third option – undertaking a collaborative project with an allied nation that will incorporate many of the systems Canada wants into a joint design. This may require a unique organizational structure as has been the case with the CSC program where Irving is the prime contractor. Whichever choice the government selects, it may benefit from the project management experience cultivated during the CSC program.

CSC is a highly complex program that has involved many layers of decisions and considerations for it to reach the state it is at today. Its issues, including program delay, defy easy resolution. Many of the broader program decisions, such as interoperability, or the development and maintenance of a domestic industrial capability, are long-held objectives of the government of Canada and DND. Others, like the unique program structure, came about during the program's development as a result of factors that arose at the time.

Understanding just how those circumstances emerged and how they affected not just the CSC program but how they will affect other, future programs is a worthwhile objective that can improve outcomes for Canada and the Canadian Armed Forces.

About the author



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Endnotes

1 Interview with retired RCN officer, June 10, 2021.

2 Initially this program was known as the Command and Control Area Air Defence Replacement (CADRE) (Canada, Department of National Defence 2020, 4).

3 Interview with retired RCN officer, July 24, 2021.

4 Interview with retired RCN officer, October 5, 2017.

5 The only sole-sourced program was the Leopard 1 belly armour upgrade.

6 Interview with former DND official involved in procurement, October 19, 2021.

7 Interview with former DND official involved in procurement, October 19, 2021.

8 Interview with retired RCN officer, July 24, 2021 and retired RCN officer, June 10, 2021.

9 Interview with retired RCN officer, June 10, 2021.

10 Interview with former DND official, August 2, 2021.

11 Interview with former DND official, August 2, 2021.

12 Treasury (Department of Finance); Department of National Defence and the Assistant Deputy Ministry (Materiel); the Military; Innovation, Science and Economic Development Canada; Public Services and Procurement Canada; and the selected contractor.

13 Interview with former DND official, August 2nd 2021.

14 Interview with former DND official, August 2, 2021.

15 Interview with retired RCN officer, July 24, 2021.

16 Ibid.

17 Ibid.

18 Ibid.

19 Ibid.

20 Interview with retired RCN officer, June 10, 2021.

21 Interview with retired Royal Canadian Air Force (RCAF) officer, May 18, 2017 and former senior DND official, October 19, 2021.

22 Interview with retired RCAF officer, May 18, 2017.

23 Data complied using the Lobbyist Registry maintained by the Office of the Commissioner of Lobbying of Canada. Available at https://lobbycanada.gc.ca.

24 interview with US government naval design specialist, April 20, 2021.

25 Interview with former DND official, August 2, 2021.

26 The PBO's modelling in 2011 predicted an "average unit acquisition" of $148 million per aircraft after 750 aircraft were produced. With 750 aircraft now having been delivered, the actual cost for those aircraft is roughly $75 million to $85 million: the variance is due to uncertainty around ex-actly what the PBO model includes in order to make a like-to-like comparison (United States, Department of Defense 2019).

27 Interviews with retired RCN officers, June 10, and July 24, 2021.

28 Interview with retired RCAF officer, May 18, 2017.

29 Interview with private industry member, November 12, 2021.

30 Interview with former DND official involved in procurement, October 19, 2021.

31 Data complied using the lobbyist registry's monthly communication reports maintained by the Office of the Commissioner of Lobbying of Canada. Available at https://lobbycanada.gc.ca. To be fair, however, some of that business was also related to other areas such as NORAD radar renewal. Nevertheless, the increase in meetings was significant over other years.

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