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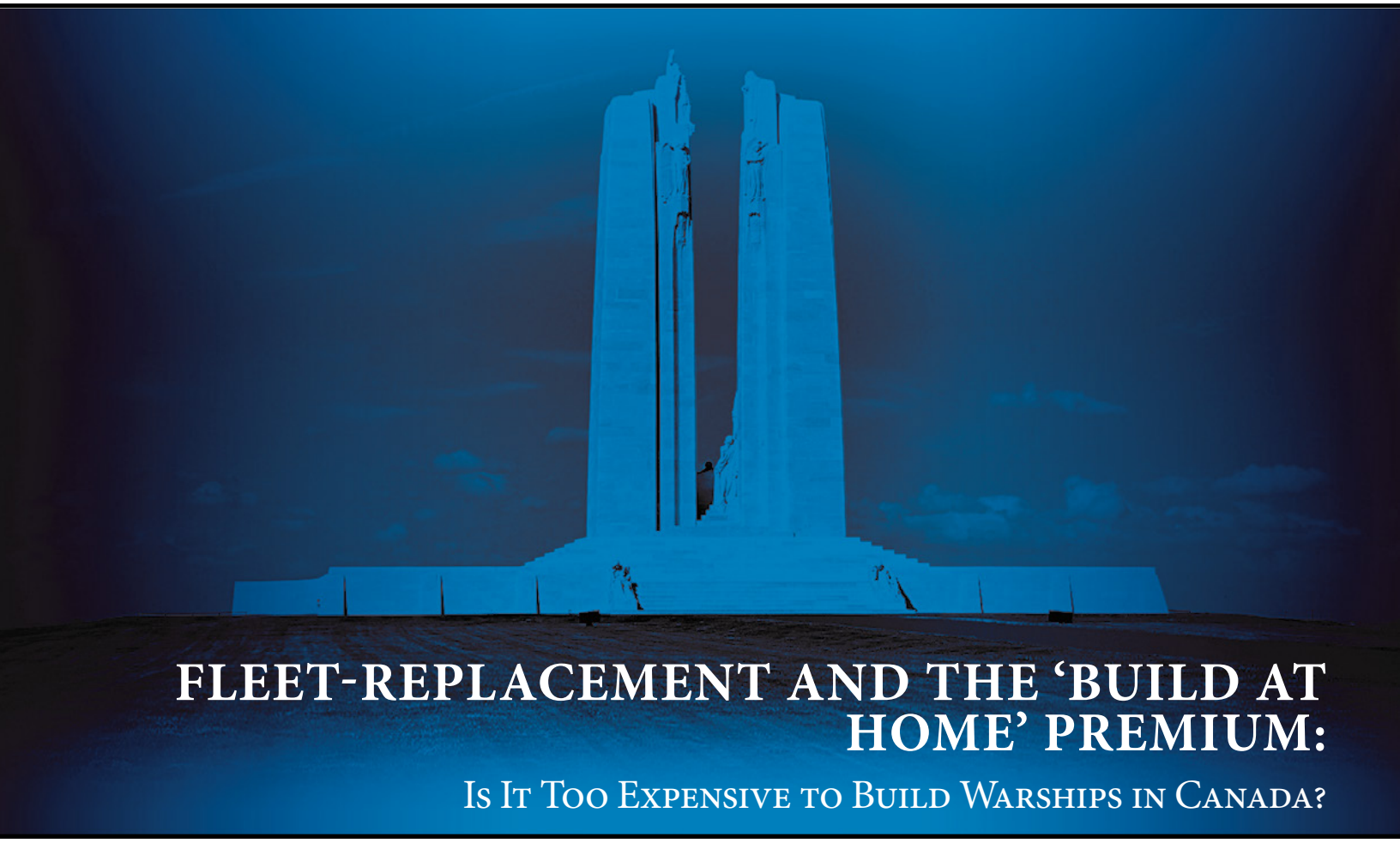

FLEET-REPLACEMENT AND THE 'BUILD AT HOME' PREMIUM:

Is It Too Expensive to Build Warships in Canada?

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EXECUTIVE SUMMARY

Canada's National Shipbuilding Strategy (NSS) has been criticized by those who argue we are paying too high a price for the 'made in Canada' option for replacing our Navy and Coast Guard fleets. Some even suggest we are paying 5-8 times more than what foreign shipyards are charging for similar ships.

In order to more precisely establish the "made in Canada" premium, this Vimy Paper first seeks guidance on warship costing. NATO's Ship Costing manual provided it and outlined in simple terms what should be included in ship costs and what should not. The paper then reviews the government's 1999 Canadian Patrol Frigate (CPF) evaluation, which compared the CPF with other western frigates and found its cost to be seven percent more while also providing a superior warship. It also examines a 2014 RAND study commissioned by the Australian government that sought to assess the true cost of its 'made at home' ships. Their open methodology allows the insertion of Canadian labour rate, industrial efficiency and warship data, which demonstrates Canada enjoyed significantly lower labor costs and likely higher yard efficiencies as a result of NSS-induced improvements. The data also suggests Canada is paying no more than a 10 percent premium for its ships base-lined against the United States, compared to Australia's 30 to 40 percent premium.

Canada's earlier shipbuilding policy combined a wasteful 'boom and bust' approach with a political desire to spread limited shipbuilding contracts to as many shipyards as possible. Tied to these are federal government defence procurement practices that added administration, insurance, taxes, salaries, and pension costs to individual ship projects in a manner few of our NATO partners accept. The evidence indicates many countries do not count or 'bury' these costs. However, in Canada these combined political and administrative 'premiums' are added to a ship's cost even though they are often larger than the actual contract value of the ship.

Today, the NSS has almost entirely eliminated the potential for 'boom and bust' cycles and the regional distribution of large ship work for political ends, although vigilance is required. That strategy has also mandated the two NSS selected shipyards to meet top quartile industrial efficiency and an engaged and highly qualified third party assessor to ensure that standard. What remains to be done is to lower the Canadian administrative premium that adds costs to our ship projects no other nation accepts and to better report construction costs to Canadians. In parallel we all have a responsibility to challenge 'too good to be true' foreign ship prices. We should begin by asking if they are following NATO's costing protocols and using a standard cost reporting metric like 'sail away cost.' When 'apple to apple' comparisons are used, the chance of foreign ships costing five to eight times less than Canadian ones approaches zero.

SOMMAIRE

La Stratégie nationale de construction navale (SNCN) fait souvent l'objet de critique par ceux qui avancent que nous payons un prix trop élevé pour l'option « fabriqué au Canada » pour remplacer les flottes de la Marine et de la Garde côtière. Certains suggèrent même que nous payons de 5 à 8 fois le prix que réclameraient des chantiers navals étrangers pour des navires comparables.

Pour établir plus précisément ce que le « fabriqué au Canada » ajoute en terme de majoration des prix, ce cahier Vimy explore d'abord le coût des navires de guerre. Un indice des prix a été trouvé dans le guide de prix des navires de l'OTAN, qui fournit et décrit en termes simples ce qui devrait et ne devrait pas être inclus dans les coûts d'un navire. Ensuite, le cahier Vimy examine l'évaluation de la frégate canadienne de patrouille (FCP) effectuée par le gouvernement en 1999 qui compare son coût avec celui d'autres frégates de pays occidentaux et qui estime que le coût de la FCP était de 7 pour cent supérieur à celui de ses comparateurs, tout en offrant un produit de qualité supérieure. Le cahier se penche également sur une étude commandée par le gouvernement australien et menée par l'entreprise RAND en 2014 qui a cherché à évaluer le coût réel des navires « fabriqués au pays ». La méthodologie ouverte utilisée par cette étude a permis de prendre en compte les coûts canadiens de la main d'œuvre, l'efficacité industrielle et les données touchant les navires de guerre. L'étude a démontré que le Canada bénéficie d'un coût de la main-d'œuvre bien inférieur et jouit probablement de meilleurs rendements de chantier grâce à des améliorations provoquées par la SNCN. Les données suggèrent également que le Canada paye une prime au plus de 10 pour cent pour ses navires par rapport à ceux des États-Unis, alors que la prime pour les navires australiens se chiffre entre 30 et 40 pour cent.

La politique antérieure de la construction navale du Canada a combiné une approche gaspilleuse d'alternance de hausses et de baisses suite à une volonté politique de répartir des contrats de construction navale limitées à autant de chantiers que possible. Liées à ces politiques sont les pratiques du gouvernement fédéral en matière d'approvisionnement qui ont ajouté les frais d'administration, les assurances, les impôts, les salaires et les coûts de pension à des projets individuels d'une façon que peu de nos partenaires de l'OTAN acceptent. Les données indiquent que de nombreux pays ne comptent pas ou simplement camouflent ces coûts. Toutefois, ces « majorations des prix » politiques et administratives combinées sont ajoutés au coût d'un navire au Canada, même si elles sont souvent plus grandes que la valeur réelle du contrat du navire.

Aujourd'hui, la SNCN a presque entièrement éliminé le risque de cycles de hausses et de baisses et la répartition régionale des travaux de grands navires pour des objectifs politiques, bien que la vigilance soit nécessaire. Pour s'assurer que les normes soient respectées, cette stratégie a également exigé que les deux chantiers navals sélectionnés par la SNCN aient prouvé l'efficacité industrielle dans le quartile supérieur et qu'un évaluateur du tiers hautement qualifié ait été présent. Ce qu'il reste à faire est de faire baisser la prime administrative canadienne, qui ajoute des coûts à nos projets de navires qu'aucune autre nation accepte, et d'assurer que des rapports précis sur les coûts soient communiqués au public d'une manière plus efficace. En même temps, nous avons tous la responsabilité de contester le « trop beau pour être vrai » prix des navires étrangers. Nous devrions commencer par se demander si ces prix suivent les protocoles d'établissement des coûts de l'OTAN et s'ils utilisent des indicateurs de coûts standards comme celle du coût d'appareillage. Quand des comparaisons équitables sont utilisées, il reste moins de possibilités que des navires étrangers coûtent cinq à huit fois moins que celles du Canada.

INTRODUCTION

Both the Conservative and Liberal governments' have committed to a National Shipbuilding Strategy (NSS) to rebuild both the Royal Canadian Navy (RCN) and Coast Guard fleets. Yet this has done little to dissuade critics who claim that building in Canada is too expensive. Last year, CBC reporter Terry Milewski argued we were paying five times what the Koreans might charge for our supply ships and seven times what a Polish built Arctic patrol ship would cost.[1] The UK recently opted to have their replenishment ships built in South Korea, leading Jack Granatstein to ask "[s]hould the RCN ships cost eight times those of the British?"[2] Data contradicting these claims is rarely noted.

Yet in 1999, Canada's Chief of Review Services (CRS) – the audit arm of the Department of National Defence (DND) – did a comparison of the Canadian Patrol Frigate's costs against seven western-built warships and found that "the production cost for the last ship is reasonably competitive with other nations."[3] More recently, Kevin McCoy, the president of Irving Shipbuilding stated "Canada should pay no more for their warships than other nations with like-minded aspirations."[4] As University of Calgary's Timothy Choi argued in 2014, with the "radical bottom-up reconstruction" of Canadian shipyards now underway, "the costs of carrying out the NSPS program may actually be *less* than predicted." Moreover, he concluded these reforms may result in Canadian ship prices low enough to attract export orders.[5]

While there has been a traditional readiness for our governments to pay a modest but unstated premium to build at home, too high a premium now could erode public support for the entire strategy or result in more expensive and thus fewer or less capable ships. This paper will seek to determine how much extra Canada is likely to pay for building here. As a huge disparity already exists on what some consider the likely premium to be, the paper will also attempt to recommend measures that would ensure Canada is paying the least possible premium for its ships and, additionally, note how better reporting of ship costs could assist in this endeavour.[6]

The 'made in Canada' premium is defined as that additional cost that must be added to a warship purchase as a result of it being built domestically, normally expressed as a percentage of the cost of a theoretically cheaper foreign built ship. I will seek to use an 'apples to apples' comparison, despite the endemic failure of the ship costing literature to use common terms. This will normally mean that if a foreign warship's advertised costs do not include some of the costs government policy insists the Canadian built ship carry, like sales tax, it will be noted but not counted.[7]

Not surprisingly, the first part of this discussion will begin with a short explanation of warship cost terminology. Here the focus will be on which ship construction costs should be included and which should

not. Next, the 1999 CRS study of the Canadian Patrol Frigate (CPF) will be closely examined for its present day applicability. Then this paper will turn to the 2014 RAND report *Australia's Naval Shipbuilding Enterprise: Preparing for the 21st Century*, which examines the country's recent warship construction approach.[8] I will be making the case that this more recent study has very direct lessons in cost premiums and shipbuilding efficiency for Canada's NSS. The third part of the paper will briefly examine other Canadian studies that can assist. The final part will attempt to assess a 'made in Canada' premium and list what needs to be done to ensure both lower and more accurate ship costs.

I must also clarify my limitations and my intent. The costing of billion-dollar warships is a complex task, as Commander David Peer made clear in a detailed examination of the costing problem.[9] This is why well-funded groups like the DND's Chief of the Review Services, the RAND Corporation, and the Canadian Parliamentary Budget Officer normally undertake them. They rely on complex costing models and are often able to source the cost data all the way back to their origin. This is well beyond my skill or resources. What I am able to do is validate their conclusions, ensure their efforts were consistently applied, and, occasionally, insert Canadian data into their models. In the end, my efforts will not be able to provide a precise percentage figure for the 'made in Canada' premium. Rather, I will generate a range of values much as these more elaborate studies did.

Warship Costing Terminology

There has always been confusion in ship costing terminology, a fact exacerbated by the inability or unwillingness of states to provide complete cost data on their warship acquisitions. Over time, however, many Western navies have adopted or partially adopted the NATO costing conventions contained in *Allied Naval Engineering Publication (ANEP) 41 - Ship Costing*. The document's aim was to "serve as a reference document to enable comparison of costs between nations" while also assisting NATO collaboration.[10]

NATO's *Ship Costing* established three broad types of costs: "sail-away cost," "program acquisition cost," and "life cycle cost." "Sail-away cost" – or "initial construction cost" – is the cost to purchase a single ship, plus a small portion of program management (but not program management team salaries), test and trials, initial onboard spares, tools, and fuel.[11] It is occasionally referred to elsewhere as the "export price," the "purchase price," or the "unit procurement cost." Most significantly, "sail-away costs" do not include the ship's design and development or the extra costs to build the lead ship, which when combined with the sail-away cost form part of a ship's larger "program acquisition cost." That larger cost also includes the price of such recurring or common items like software, facilities in direct support of the ship or its construction, ship training, and technical data. In Canada, this is often referred to as the "project cost."[12] Finally, one has the "life cycle costs" and these include all of the personnel costs (including pay), fuel, and

repair costs of operating a ship over the thirty to forty years of its life with the project acquisition cost. This figure is usually immense and consideration of it adds relatively little to discussions of 'made in Canada' premiums because it involves operating and crew costs that kick in well after the ship is made.[13]

CRS Canadian Patrol Frigate: Cost and Capability Comparison 1999

The Canadian government's review of the CPF project was intense. The Project Manager reported being audited sixteen times before the CRS audit.[14] The Chief of Review Services report itself was one of a series of five government documents that attempted to respond to public criticism of the Canadian Patrol Frigate Project. While other documents addressed the CPF's budget, training facilities, conflict of interest allegations and security, the CRS report focused on a comparison of the CPF's costs and capability with seven to eleven other western frigates.[15] Worldwide, only two other public studies attempted the CRS' cross-nation warship comparison and these were done much later. The CRS report began, first, with a comparison of the fighting capability of the CPF compared with its Western equivalents. The results were summarized in Table 1.

This table convincingly demonstrated how the Canadian Patrol Frigate was superior to all of the ships under consideration, with the possible exception of "Ship 5" which was its apparent equal.[16] Little of this was subjective, and its Annex A provided pages of warship specifics to allow a ship-to-ship measuring of

Table 1 - CPF Capability Comparison With 11 Frigates From Other Nations

Capability (Subsystem Groupings)	CPF	Ship 1	Ship 2	Ship 3	Ship 4	Ship 5	Ship 6	Ship 7	Ship 8	Ship 9	Ship 10	Ship 11
Multi-purpose Roles												
Range, Crew Size												
Surface to Surface Weapons												
Air Defence												
Sub-surface Weapons												
Surface/Sub-surface Detection												
Close in Defence												
System Integration												
Survivability												

CPF Superior CPF Equivalent CPF Inferior

Source: Canada, DND, *Chief of Review Services Report on Canadian Patrol Frigate Cost and Capability Comparison* (7050-11-11, 1999), p. 5/13. The CRS report also provides a fuller explanation of the capabilities measured and the justification for their ratings at pages 4-7/13 and at its Annex A and B.

the actual capability differences. In more subjective areas like "survivability" or "systems integration," the report relied on highly regarded outside assessors, such as the US-based group Forecast International. The latter's views on the CPF's survivability were:

> The deep draught and fine bow lines reduce the tendency of the sonar dome to lift clear of the water, cut slamming, and minimize pitching and rolling on the main deck. These features, as demonstrated in service, coupled with extensive subdivision and a generous reserve of buoyancy, contribute to survivability with large angles of stability and a high degree of damage tolerance.[17]

The journal *Maritime Forces* assessed system integration concluding:

> The Canadian Navy and Unisys GSC deserve great credit for getting the first fully distributed surface ship command system into service. The City class patrol frigates have the Shipboard Integrated Processing and Display System (SHINPADS), a system which has impressed all who have seen it in action. What makes SHINPADS so advanced was the early recognition by the designers of the changing options in combat system architecture. A study initiated 20 years ago concluded that computer hardware costs were falling rapidly, and that single central processing computer systems were becoming obsolete.[18]

One had to go elsewhere for a more detailed look at some of the CPF's competitors from the CRS report, although it did hint at some of these.[19] Ship 1, the British Type 23, was described by the respected journal SIGNAL as a "worst-case scenario" of combat system "disintegration," noting: "The first seven ships, F230 to F236, were at sea for more than 10 years without any combat display system at all."[20] Ship 2, the USS Oliver Hazard Perry-class frigate (FFG-7) – representing the "low" component of the US Navy's "High/Low Mix" of ships – were initially delivered without a naval tactical data system or towed array. The US General Accounting Office also found the FFG-7 "unable to accommodate any new equipment beyond what is planned, unless compensating removals are made" as a result of "low margins" in the ship's design, as compared to what Forecast International called the CFP's "generous margin" for future growth.[21] Ship 4 is undoubtedly the French Lafayette-class, which the CRS report makes clear lacked a sonar, towed array, and anti-submarine torpedo tubes.[22] While the CPF had all of these and had international experts validate that it was capable in all warfare areas, the Lafayette had no anti-submarine warfare capability at all (save from its helicopter) and its anti-surface and anti-air weapons were inferior to the CPF (see Annex A). In fact, by Ship 7, the small size of some of the ships (two were half the tonnage of the CPF) and their modest capabilities suggest a very limited basis for comparison.

Nevertheless, the CRS report successfully made the case that CPF was the combat equal and more often

the superior to the six dominant Western frigates of the era.[23] Conducting the parallel cost comparison with the CPF's competitors was significantly more challenging. First, the report noted that it lacked the data needed to derive sail-away costs for two of the eleven ships under comparison. Further, the report points out that four of the remaining nine ships had project costs that were smaller than their sail-away costs, for all practical purposes an impossibility under NATO rules. Third, while the report applied *ANEP-41* data rules in determining sail-away costs, it modified NATO's program acquisition cost criteria to derive its separate "project cost" by eliminating design costs here also.[24] As the report admits, some of its external reviewers had pointed out that eliminating design costs skewed the project cost calculations in favor of the twelve ship CPF programme (and other smaller ship runs) by eliminating the benefit of those ships with longer production runs, such as the fifty-one ship US FFG-7 (Ship 2).[25]

The CRS was justified in doing so. Design costs are exceedingly difficult to determine as they comprise a mix of earlier government funded research (often into combat systems), carry over from previous ship designs, as well as separate prime contractor and subcontractor design efforts, software development, and systems integration costs. Most states, as a result, do not separately list this data. The US does, in part because it closely follows the NATO costing conventions, has capable staffs who track that information, as well as a Congress that demands good procurement data. This is relatively clear with Ship 2's cost (the FFG-7). The tables show a realistic 37 percent greater project cost than sail-away cost, and the ship's costs are in line with Forecast International and US Department of Defense data.[26] However, at the time of the FFG project (1973-1989), the Congressional Budget Office reported that "the Navy did not pay for detailed design work with production funds as it does now."[27] During the FFG-7's building it was paid out of separate research and development funds. Moreover, the FFG-7 project could rely on the 70,000 personnel of the US Navy's Sea Systems Command, over half of which are devoted to the design, oversight, and construction of new warships.[28] This organization has no Canadian equivalent.

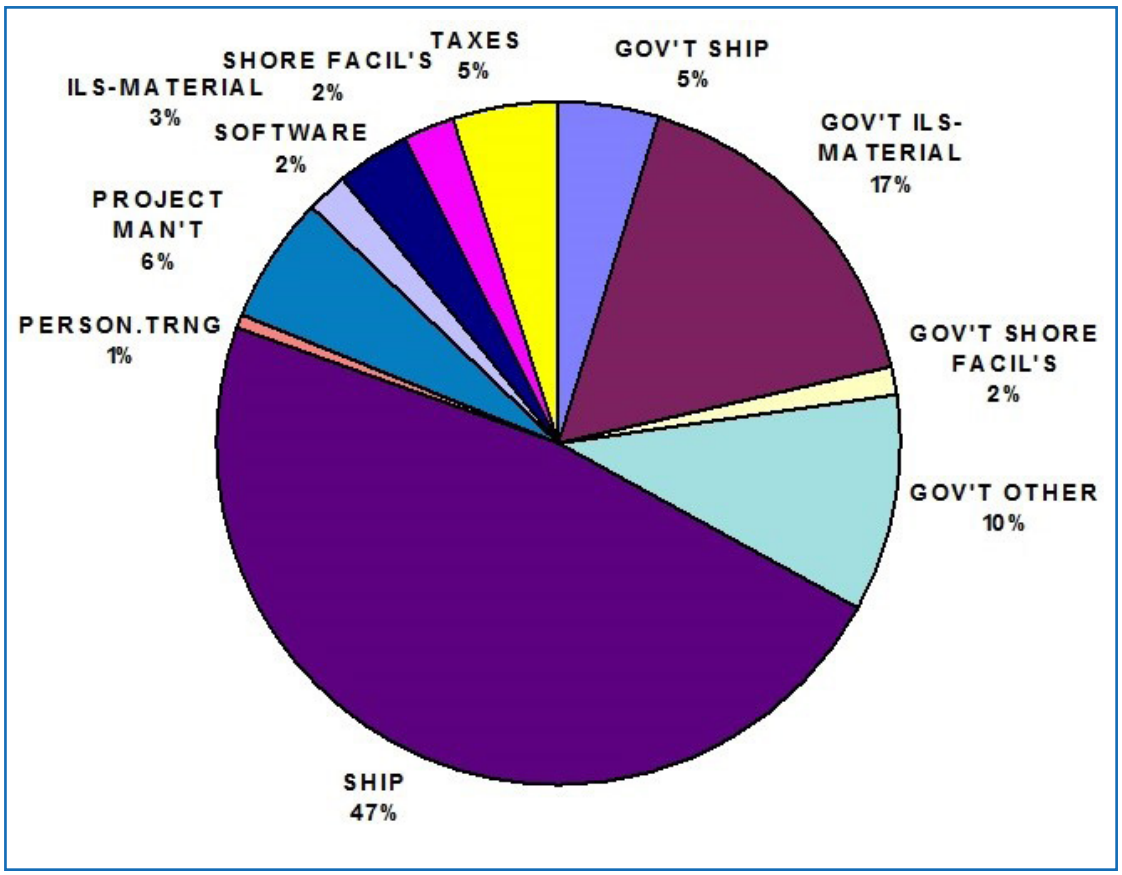
Rather, Canada relies on project management staffs to oversee ship design and building. Significantly, their members' salaries and benefits are paid by the acquisition project itself.[29] The CPF project included over four hundred personnel in its peak years from DND, Public Works and Government Services Canada (PWGSC), and myriad others including the Departments of Industry, of Justice, and of Regional Industrial Expansion.[30] These staff's salaries and benefits added at least $308 million dollars directly to the CPF project's costs (see Annex A). Significantly, neither NATO nor the US government permits the inclusion of salary or benefits (including pensions) in their project management calculations, adding another complication to cross-nation comparisons for Canada.[31]

Such comparisons were also complicated by rather dramatic national differences in the mundane issue of initial spare parts – a component of both acquisition and sail-away costs. In the Canadian Patrol Frigate

project, $999 million was spent purchasing thirty years of marine engineering spares and ten years of combat systems parts, the equivalent of $83 million per ship.[32] For the FFG-7, the United States only provided sufficient spares to "support uninterrupted operations for ninety days" and this resulted in spending US$3.5 million per ship, with one US report suggesting even that was "excessive."[33] The US approach would ultimately prove far closer to NATO's later-developed two-year cap on initial spares.[34] In addition, as Figure 1 shows, the CPF project paid over $464 million (CY 1995) in either Federal Sales Tax or the Goods and Services Tax. While NATO costing rules allows this, the US government pays no sales tax at all on its acquisitions, further confounding attempts to compare Canadian and US construction costs unless this component is removed from both.[35]

Figure 1 shows with considerable clarity the broad range of indirect or non-"Ship" costs that made up the CPF's project's total $9.3 billion (BY) cost. Significantly, "Ship" costs comprised but 47 percent of the total

Figure 1 - CPF/SRP II Revised Budget Allocation BY



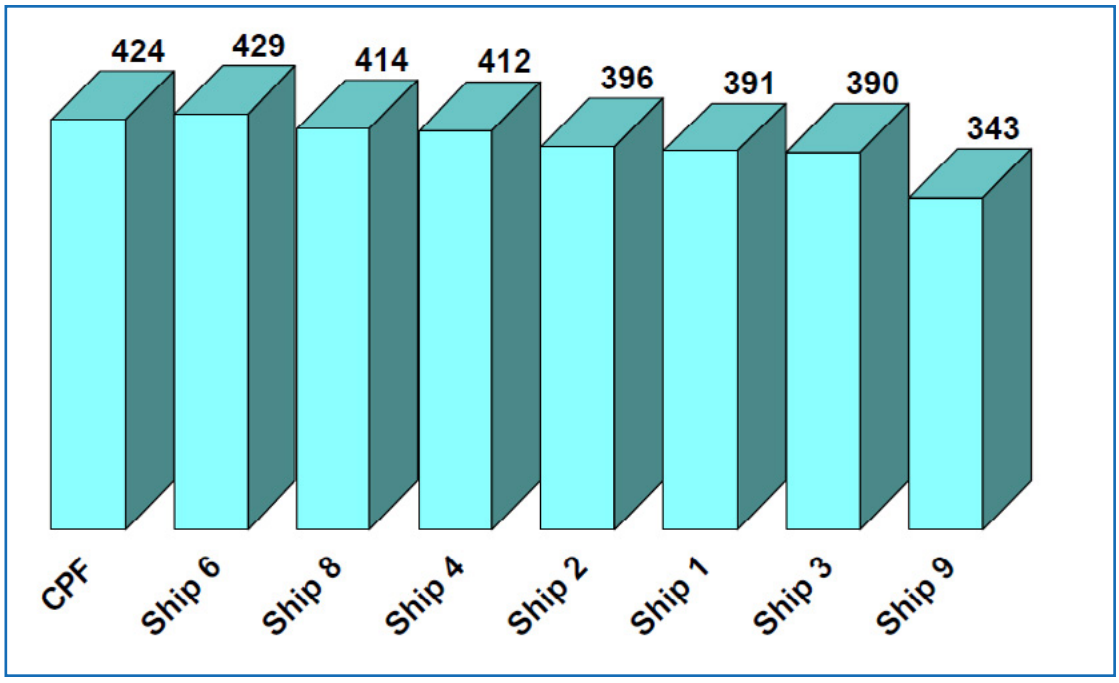
Source: Canada, DND, *Canadian Patrol Frigate Project Completion Report* (DGMEPM), Ottawa, 27 July 2005, p. 39. Details on the categories shown in the figure can be found in the report's Chapter 5 for general financial data, and Chapter 12 for Integrated Logistic Support, and Chapter 13 for shore facilities, training and software. Despite the 'SRP II" in the title, this figure represents the total 12 frigate CPF budget. The 'ILS" in the figure refers to "Integrated Logistic Support" and it went beyond pure "logistics" and included "elements of maintenance, supply, shore facilities, personnel, training and documentation" (p. 116).

cost, with such items as project management, very generous spares, taxes, insurance, training and facilities making up the remaining 53 percent.[36]

In retrospect many of these indirect costs seem excessive. However, when the CPF project began, NATO's *Ship Costing* guidance was just being developed. Further, caution was the order of the day after the "soaring cost escalation" seen during the construction of Canada's earlier DDH 280 project.[37] Therefore a formal insurance policy costing $108M against CPF cost overruns was deemed prudent. Further, the earlier DDH 280 project had purchased no spares, and the naval engineering staffs ensured that error would not be repeated with the CPF. Finally, there was an urgent need to grow project management staff then just as there is today; as noted earlier, unlike the US Navy, Canada does not maintain large permanent staffs dedicated to this task. However, why the government collected taxes on its own purchases is not clear. Moreover, the evidence is starting to suggest that Canada adds far more to its 'non-ship' project costs than other nations do or NATO recommends.

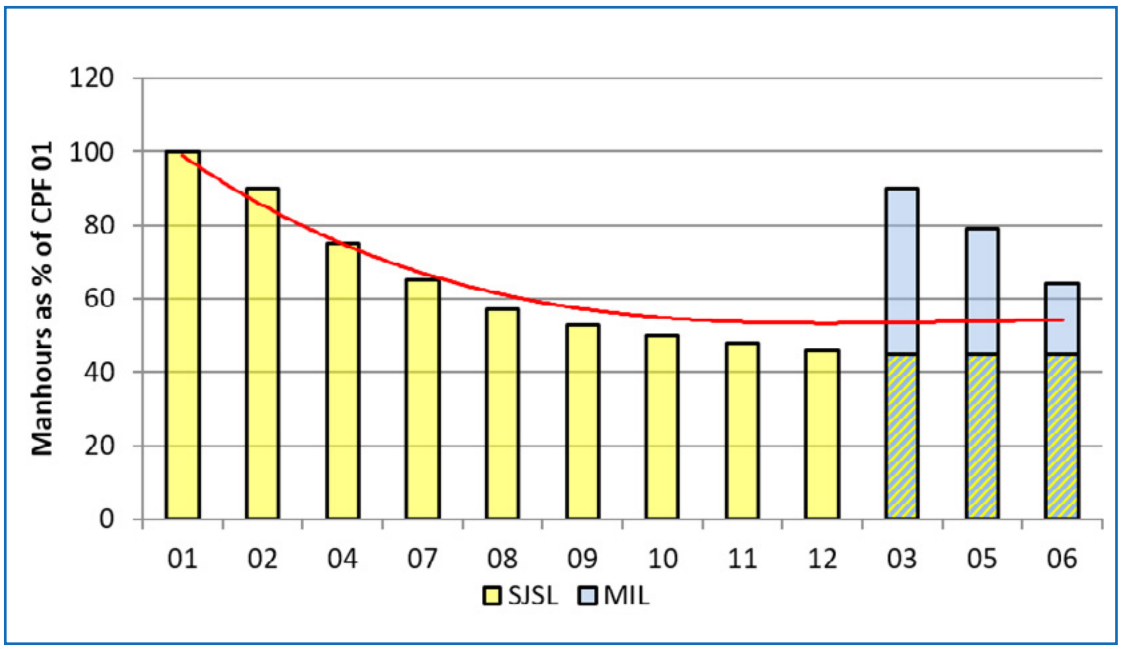
So while the CRS report also tabled a "project cost" comparison, its major finding was based on its comparison of the significantly less problematic sail-away costs which does not include many of these disputed ancillary categories involving design, tax, facilities, or insurance. In addition, the CRS staff followed NATO costing guidance closely in doing so.[38] The CRS approach of using sail-away cost was thus the best method

Figure 2 - CPF Sail-away Cost Comparison With Frigates From Seven Nations ($M)



Source: Canada, DND, *Chief of Review Services Report on Canadian Patrol Frigate Cost and Capability Comparison* (7050-11-11, 1999), p. 10/13. It also noted, correctly, that "Design, facility, depot spares, PMO, documentation and training costs are not included in NATO sail-away costs."

Figure 3 - Saint John Shipbuilding Limited (SJSL) & Marine Industries Ltée- Davies (MIL) Learning Curve



Adapted from: Canada, DND, *Canadian Patrol Frigate Project Completion Report* (DGMEPM), Ottawa, 27 July 2005, p. 101, with additions by David Peer.

to achieve an 'apple to apple' comparison of warship costs across nations.

The final result is shown in Figure 2. The listed CPF sail-away cost of $424 million (CY 1995) is for the last CPF, with the report noting the first cost $480 million. This table is also the basis for the CRS declaring that "the production cost for the last ship is reasonably competitive with other nations."[39] That cost was within 7 percent of the average cost of the seven western warships shown.[40]

This finding was not contested during the CRS report's review, with the reviewers including the Office of the Auditor General.[41] Selecting only the last and cheapest ship as the basis for international comparison is also justified if one examines Figure 3. It shows in light blue the added effort and costs generated by the entirely political decision to split the work between the prime contractor, Saint John Shipbuilding Limited (SJSL), and the Marine Industries Ltée- Davies (MIL) yards in Quebec. This transfer of three of twelve CPF builds to Québec was done "to ensure equitable distribution of regional benefits" in the words of the DND/PWGSC Report.[42] That that decision added cost is clear from the diagram.

On a more encouraging note, the graph shows that construction efficiency at the Irving yard in Saint John was meeting or exceeding the red line of a widely accepted international shipbuilding learning curve.[43] With only three ships being built in Quebec in two different yards – one in Montreal and one in Quebec City – Marine Industries Ltée (MIL) had no realistic chance of producing a similar learning curve over

a three ship construction run especially as they were relying on traditional shipbuilding methods. Nevertheless, their brief three ship curve was on a positive trend line. However, as they were achieving it, both MIL and SJSL became embroiled in a series of disputes leading to "total breakdown in relations by 1991" and then extended legal battles.[44] In the end, only the Irving yard in Saint John was assigned the work for the final six CPF.

Table 2 shows the same regional distribution process was also at work in assigning Canadian Coast Guard ship construction work over the 1970-80s, as outlined recently by the Parliamentary Budget Officer.[45]

With most of the work being passed out as single ship contracts to individual yards to produce one ship only, there would be no learning curve to efficiency in seven of the nine selected yards. Only the two Quebec yards had the possibility to do so, although even that is doubtful given that different ship classes were being built with long intervals between them.

Thus the CPF was part of a Canadian shipbuilding process that built government ships via a 'boom and bust' approach of intermittent "booms" in shipbuilding followed by long "bust" periods where nothing was built. Before the Canadian Patrol Frigate no major warship had been built for fifteen years. After the CPF, nothing was built for nineteen years during which time the lead shipyard was closed and its workers

Table 2 - Canadian Coast Guard Ship Construction

Ship	Construction	Shipyard	Province
Louis St. Laurent	1969	Canadian Vickers	PQ
Pierre Radisson	1978	Versatile	PQ
Des Groseilliers	1982	Port Weller	Ont
Henry Larsen	1987	Versatile	PQ
Griffon	1970	Davie	PQ
Edward Cornwallis	1986	Marine Industries	PQ
George R. Pearkes	1986	Versatile	PQ
Sir Wilfrid Laurier	1986	Collingwood	Ont.
Martha L. Black	1986	Versatile	PQ
Sir William Alexander	1987	Marine Industries	PQ
Ann Harvey	1987	Halifax Dartmouth	NS
Samuel Risley	1985	Vito Steel	BC
Earl Grey	1986	Pictou	NS

Adapted from: Canada, *Budget Analysis for the Acquisition of a Class of Arctic/Offshore Patrol Ships* (Ottawa, PBO, 2014), Table B-1, p. 27, http://www.pbo-dpb.gc.ca/web/default/files/files/files/AOPS_EN.pdf

and engineers let go. This process was further comprised by the above-noted regionally distribution of the boom periods' shipbuilding work to shipyards both large and small. As seen earlier in Figure 3, the resulting inefficiency directly added to the frigates' overall costs.

Thankfully, the CRS report's use of sail-away costs allowed a meaningful presentation of the frigates' actual 'made in Canada' cost and provided the basis for an 'apple to apple' comparison with other nations. Further, the evidence is starting to demonstrate that purported high 'made in Canada' costs have more to do with a faulty government shipbuilding policy and the growth of the government administrative costs than any problem with our actual manufacturing industries.

However, while the CRS report adequately compared CPF capability and then cost, it did not directly relate the two. It was left to the reader to assess the extent to which the CPF's greater combat capability was worth its seven percent higher cost. However, the next study provides a method to do so. It, too, relied on a comparison with the US FFG-7 and this provides a common performance and cost baseline that allows the near-direct transfer of CPF data into that more recent study.

Australian National Shipbuilding Enterprise (ANSE) Report 2015

The Australian Department of Defence engaged the RAND Corporation to examine their shipbuilding industry, suggest alternate approaches, and gauge the 'made in Australia' premium for its warships.[46] Given that the Australian warship shipbuilding experience was also one of 'boom and bust' offset by their Navy's desire for advanced warships, there were obvious parallels to Canada. Indeed, the Canadian media quickly noted recent Australian problems of high cost and over-budget ships and suggested that trend could continue here.[47]

The Australian study too had difficulty extracting national ship cost data, especially from South Korea, and to a lesser extent Japan and Spain. It also relied on a modified form of sail-away cost, which it termed the "unit procurement" or "purchase price" and that specifically did not include design costs, much like the DND CRS study.[48] Yet, their costing is not entirely 'sail-away,' as they later admit that the extent to which "all of the support, management, and investment costs are fully reflected in the ship prices is unknown." This uncertainty over the ability to capture all programme costs was also the case for the two other major studies this analysis relied on.

The RAND report also attempted to overcome problematic data quality by examining a spread of inputs (shipyard labour rates, broad industry construction costs, productivity) rather than relying entirely on problematic international warship costing data. Many of these input data sources remain available on the

internet and are pulled from credible sources, like the US Bureau of Labor. As noted, the RAND report also based-lined its frigate costs on the FFG-7, allowing a direct correlation with the CRS study. Importantly, in each of these input areas they also use a spread of values from "low" to "high" rather than seeking a precise value – a clear recognition of the imprecise nature of some national costing data. Finally, an effort was made to introduce some recognition of capability differences by using the widely accepted cost per ton metric in lieu of pure cost alone. Their work is well summarized in Table 3. As this table shows, Australia is paying a 30 to 40 percent 'made at home premium' for its warships against a US baseline and the input data from Australian labour and construction costs correspond closely to that price premium.

My intent will be to input like data for Canada and make similar comparisons for frigates. This begins with the RAND report table showing shipbuilding wages in Australia against those of other states. I have added in red the 2013 Canadian data from Industry Canada which uses the same "3366" index as the

Table 3 – Summary Metrics for Australian Shipbuilding Costs Relative to a US Basis

Method	Metric	Approximate Australian Premium Relative to a U.S. Basis (%)
Input	Direct shipbuilding labor wages	40
	Manufacturing labor costs	35
	Oil and gas industry construction	20
	Construction cost adjusted to First Marine International shipbuilding productivity[a]	45
Comparative	Frigate costs	40
	Destroyer costs	30[b]
	Amphibious ship costs	12[c]
Parametric		35

[a] Cost comparison based on hours per compensated gross tonnage, a productivity measure used by First Marine International Ltd. This measure compares the weights of different types of commercial ships with one another by using adjustment factors that depend on the ship type (e.g., tanker, dry cargo, ferry). See First Marine International Ltd., *First Marine International Findings for the Global Shipbuilding Industrial Base Benchmarking Study*, Part 2: *Mid-Tier Shipyards, Final Redacted Report*, February 6, 2007.

[b] Prior to rebaseline.

[c] Based on the recent LHD. Because significant portions of the ship are built in Spain, the relative costs may not be representative of a complete Australian build (the premium is likely lower than if the ship had been fully built in Australia).

Source: John Birkler, et al., *Australia's Naval Shipbuilding Enterprise: Preparing for the 21st Century* (Santa Monica, CA: RAND Corporation, 2015), p. 125. The "Input" information is taken from 2012-2013 data. The "Comparative" data uses ship data culled from 1995 to 2014 (p. 113-114).

Table 4 - Direct Hourly Wage Rates for Boat and Shipbuilding

Country	Direct Pay per Hour	Converted Direct Pay (AUD per Hour)	Relative Pay (U.S. = 1.0)	Source
Australia	AUD 38.80[a]	38.80	139%	Australian Bureau of Statistics, "Employee Earnings and Hours, Australia," May 2013
U.S.	USD 24.50	27.84	100%	U.S. Bureau of Labor Statistics, "National Industry-Specific Occupational Employment and Wage Estimates: NAICS 336600—Ship and Boat Building," May 2013b
U.K.	£16.35	29.75	107%	U.K. Office for National Statistics, "Weekly Pay—Gross (£)—For Full-Time Employee Jobs: United Kingdom, SIC2007, Table 16.1a," 2013
Canada	**CAD 23.00**	**23.23**	**83%**	**Industry Canada Statistics 3366**

NOTE: Values are reported on a fixed 2013 basis.

[a] Value has been escalated from 2012 to 2013 to be on a comparable basis.

Adapted from: John Birkler, et al., *Australia's Naval Shipbuilding Enterprise: Preparing for the 21st Century* (Santa Monica, CA: RAND Corporation, 2015), table 5-1, with additions by author. Canadian data (in red) from: Canada, "Ship and Boat Building (NAICS 3366): Salaries and Wages," Industry Canada, Canadian Industry Statistics, https://www.ic.gc.ca/app/scr/sbms/sbb/cis/salaries.html?code=3366&lang=eng#wag1. Here one must note that the RAND intentionally benchmarked broad national pay rates for the ship and boatbuilding sectors. Shipyards with more technically complex tasks calling for more advanced labour skills pay more. In fact Irving Shipbuilding's pay rate is $33 an hour. RAND did not attempt to compare specific naval shipyard labour rates because it could not get this kind of data from other states. (p. 103).

United States Department of Labor and have done the currency conversion to Australian dollars. This can be seen in Table 4.

The logic underpinning the RAND analysis effort is that labour costs and yard productivity have a major influence on warship costs; the remaining material costs are likely to be equal given that much of the combat systems and ship machinery is purchased on the international market.[49] This is stated quite clearly:

> From the relative pay column, we can see that Australian direct pay rates are approximately 40 percent higher than US rates and 30 percent higher than U.K. rates. So, if labor cost dictated relative naval shipbuilding prices (and they are a substantial portion of those costs), then one would expect that ship

prices in Australia would be 20 percent to 30 percent higher than a US or U.K. basis.[50]

An Industry Canada analysis came to the same assessment: "Shipbuilding costs are determined by a combination of the industry's own relevant material and labor costs, and labor costs are directly influenced by productivity improvements."[51] Where the Australian shipyard rates were 38 percent higher than the US baseline rates in 2013, Table 4 shows Canadian rates were 17 percent less.

A similar trend holds true with broad hourly compensation costs which go beyond wages to include sick pay, vacation, health insurance, unemployment insurance, and payroll taxes for each country's manufacturing sector. This is shown at Table 5, modified again with the red text inclusion of Canadian data. The Canadian labor costs also come from the same US Bureau of Labor Statistics "International Comparisons" tables and show Canada's rate as 4 percent higher than the US baseline rate while Australia's is 34 percent higher.

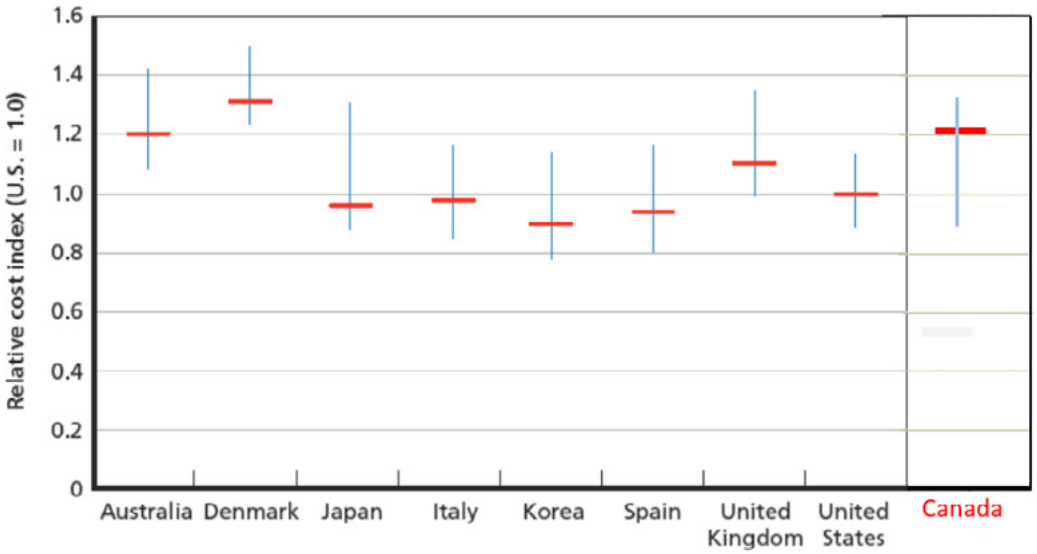
The RAND report then compares construction costs using Compass International data on the oil and gas industry, as the shipbuilding industry employs many of the same trades and contractors. This combined

Table 5 – Hourly compensation Costs in Manufacturing (2012)

Country	USD per Hour	Index (U.S. = 1.0)
Denmark	48.47	1.36
Australia	47.68	1.34
United States	35.67	1.00
Japan	35.34	0.99
Italy	34.18	0.96
United Kingdom	31.23	0.88
Spain	26.83	0.75
Korea	20.72	0.58
Estonia	10.41	0.29
Canada	**36.59**	**1.04**

Adapted from: John Birkler, et al., *Australia's Naval Shipbuilding Enterprise: Preparing for the 21st Century* (Santa Monica, CA: RAND Corporation, 2015), p. 105, with additions by author. The data is from US Bureau of Labor Statistics. "International Comparisons Of Hourly Compensation Costs In Manufacturing," May 2013 a.

Table 6 – Relative Oil, Chemical, and Gas Plant Construction Costs



Adapted from: John Birkler, et al., *Australia's Naval Shipbuilding Enterprise: Preparing for the 21st Century* (Santa Monica, CA: RAND Corporation, 2015), p. 107, with additions by author.

labor, equipment, and construction costs. In Tably 6, I adopted the same source used by RAND to derive like Canadian oil and gas costs and displayed them in red. This shows a 23 percent premium in costs over US rates and one similar to the Australian oil and gas sector.

RAND then used First Marine International shipyard productivity data to assess relative Australian construction costs. The Australian costs were assessed 45 percent higher than the US baseline, based primarily on their review of the recent Australian Air Warfare Destroyer (AWD) project, which the CBC had suggested might foretell similar problems for Canada's NSS. While the RAND report based its relative construction costs on a "compensated gross tonnage" system that included no Canadian data, the report does note those results are "consistent with the view of that program's [the AWD] performance."[52] That, and the use of the same First Marine International standards used in Canadian NSS yards still allows a broad comparison with current Canadian productivity.

Like the Quebec-built CPF, the AWD project itself relied on a distributed construction approach where they used three different yards to build large modules barged to final assembly in the Australian Submarine Corporation's (ASC) Yard. However, early on one of the modules from the contributing British Aerospace (BAE) shipyard was discovered "out of dimensional tolerance" and "distorted," forcing that yard's work to be transferred to NAVANTIA's (the warship designer) Spanish and British yards. A two-year freeze on construction at BAE followed as facilities and workforce were upgraded.[53] With five yards building modules for three destroyers, establishing a learning curve to efficiency was going to be difficult.[54]

The Australian national audit office review of the AWD confirmed this and identified problems with shipyard experience, an inadequately mature design at construction start with numerous significant changes in the design extending up to the third-year of construction, and outmoded or inadequate drawing and design tools.[55] The project relied heavily on 2-D PDF drawings, with 3-D computer-generated ones only becoming available in all three contributing Australian shipyards three years into construction.[56]

First Marine International was brought in to advise the government at construction start in order to provide an independent assessment of shipyard productivity.[57] (FMI has done such assessments in fifty countries for over one hundred and fifty shipyards over forty-five years.) Their role vis the shipyards was one of suggestion and focused on productivity improvements.[58] Three years later, however, FMI assessed only 5 percent of the issues it had raised had been "resolved," with another 24 percent partially resolved. The remaining 68 percent were "issues where little effective action had been taken" or "new issues."[59] Indeed, the project's program manager reported to the Australian auditor that the "call for improvement has not been consistently accepted by the shipbuilder."[60] Unsurprisingly, the program was late and over budget. That may have provoked the Defence Minister to state "You wonder why I'm worried about ASC and wonder what they're delivering to the Australian taxpayer? You wonder why I wouldn't trust them to build a canoe?"[61]

The situation under the current NSS in Canada is quite different, especially in the dramatically more powerful role played by First Marine International. FMI was brought as a 3rd party assessor by the Canadian government five years before construction began. It assessed which two of the five competing Canadian shipyards were likely to be able to meet international standards for efficiency, and it outlined to both winning yards precisely what productivity investments were needed. It will assess whether the Halifax and Vancouver yards have met the 'target state' production efficiency that will place them in the top quartile of shipyard productivity in the world. Once reached, one can expect an ongoing effort to maintain target state efficiency; certainly, follow-on shipbuilding contracts are understood to be conditional on them maintaining 'top quartile' standards.[62] There have been public reports that they are meeting those goals and the two yards openly supported the FMI process.[63]

In addition, both the SEASPAN and Irving yards have invested heavily in new 3-D computer aided design and manufacturing facilities and have targeted having as much of the detailed designs completed before building.[64] Both firms have also successfully delivered the earlier Halifax-class modernization project, and specifically will not be resorting to distributed construction.[65] They have, therefore, overcome many of the inefficiencies seen in the Australian AWD. Finally, the Irving yard will have a Canadian Surface Combatant workforce prepared by five years work on the Arctic and Offshore Patrol Ship. All of this suggests Canadian productivity is likely to be within the top quartile of efficiency demanded by their contracts.

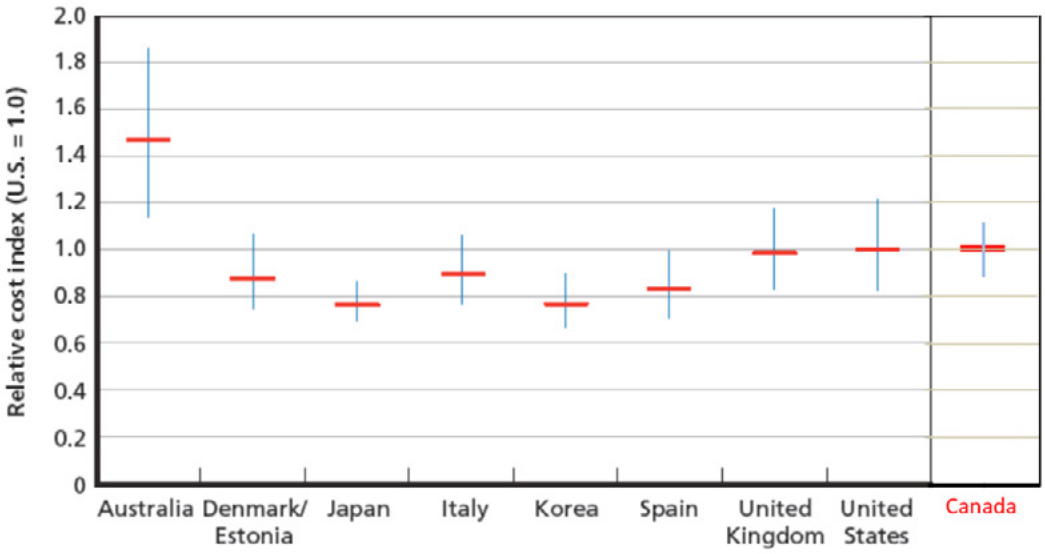
This should, as a result, mean relative costs will be in a 25 percent band centred on the US baseline as shown in Table 7.

The RAND report then compared the relative unit procurement costs for Australian frigates set against those of other nations using a cost per ton index and their data is presented at Table 8 with the Canadian frigate data shown in red. That study also assessed Australian destroyers and amphibious ships, but these do not allow direct comparisons with Canadian shipbuilding as our data is too dated.

The red "CPF" data shown is the range of CPF costs from Annex A converted to Cost Per Ton then baselined to the FFG-7.[66] Of course, this is only part of the methodology RAND applied behind the scenes, but this direct comparison of cost per ton done here certainly shows that Canada should not be expecting a significant 'made in Canada' premium.

Table 9 shows the Canadian data from the previous tables collected and displayed, again in red, save for the "parametric" data, and Destroyer and Amphibious ship costs. There is no matching recent Canadian data on the latter two, and the parametric process used within the RAND report is not accessible. Significantly, Canada's "comparative frigate costs" are congruent with the "input" data on wages, labour costs, construction, and productivity figures. Where RAND argued the Australian premium was in the 30 to 40 percent range, my inputting of like data suggests the 'made in Canada' premium for warships lies in a

Table 7 – Relative Construction Costs, Based on First Marine International shipbuilding



Adapted from: John Birkler, et al., *Australia's Naval Shipbuilding Enterprise: Preparing for the 21st Century* (Santa Monica, CA: RAND Corporation, 2015), p. 108, with additions by author.

Table 8 – Unit Procurement Cost and Relative Index Cost Data, Frigates (CPT = Cost Per Ton)

Ship	Country	Relative CPT Index[a] Low	High
F590 FREMM	Italy	0.95	1.00
D650 FREMM	France	1.18	1.24
De Zeven Provinciën LCF	Netherlands	1.00	1.07
Iver Huitfeldt	Denmark	0.56	0.62
Anzac	Australia	1.36	1.48
Incheon	Korea	0.65	0.75
Oliver Hazard Perry FFG-7	United States	0.93	1.07
LCS[b]	United States	1.42	1.44
CPF	Canada	0.79	1.10

Adapted from: John Birkler, et al., *Australia's Naval Shipbuilding Enterprise: Preparing for the 21st Century* (Santa Monica, CA: RAND Corporation, 2015), p. 108, with additions by author. The "low" cost per ton (cpt) index RAND ANSE provided for the FFG-7 is based on its average program cost, while the "high" is based on the higher costs of the later built and lengthened Flight III FFG-7. These later FFG-7s were also fitted with a towed array and a naval tactical data system (like the CPF) while the first FFG-7s were not, making the later ones much more comparable to the CFP. I have, however, followed the path of the RAND report and used both the low and high costs variants of the FFG-7 whenever I compared this ship against the CPF.

Table 9 – Summary Metrics for Australian Shipbuilding Costs Relative to a US Basis

Method	Metric	Approximate Australian Premium Relative to a U.S. Basis (%)	Approximate Canadian Premium Relative to a US Basis (%)
Input	Direct shipbuilding labor wages	40	-17
	Manufacturing labor costs	35	04
	Oil and gas industry construction	20	23
	Construction cost adjusted to First Marine International shipbuilding productivity[a]	45	-12.5 to +12.5
Comparative	Frigate costs	40	-21 to +10
	Destroyer costs	30[b]	N/A
	Amphibious ship costs	12[c]	N/A
Parametric		35	N/A

Adapted from: John Birkler, et al., *Australia's Naval Shipbuilding Enterprise: Preparing for the 21st Century* (Santa Monica, CA: RAND Corporation, 2015), p. 125, with addition by author.

band of minus 21 to plus 10 percent. Thus the CPF was broadly comparable in cost per ton terms with the FFG-7, a result not far from the 1999 CRS findings.

As was made clear at the beginning, and the widespread problems in getting reliable costing data in other studies confirm, it is not possible to provide a precise figure for that premium. The range of values provided here is, however, verifiable and closely corresponds to other studies.[67] Nevertheless, I should be ready to have other researchers expand that band. However, given the very broad range of shipbuilding data assembled here, arguments that foreign built equivalents of our replenishment and patrol ships are five to eight times cheaper must be considered doubtful in the extreme.

Other Studies

There are, regrettably, no other public studies available either in Canada or internationally that can be used in any direct way to further refine Canada's 'made in Canada' premium. However, Industry Canada commissioned the UK firm Mott MacDonald in 2008 to provide an economic analysis of Canadian shipbuilding. Tellingly, the report argued Canadian ship costs could be as high as 5 to 10 percent over the cost of foreign built ships; that "premium" reflected the value of the lost taxes, greater employment insurance payouts, and higher maintenance costs incurred if Canada bought foreign warships.[68] In fact, Irving Shipbuilding stressed that one-third of what they pay for labour comes back to the federal and provincial governments in taxes on wages and the Mott MacDonald data broadly supports that.[69] The report also noted that purchasing foreign built ships puts one at the mercy of overseas supply chains – a problem underlined in our maintenance of the Upholder-class submarines from time to time.[70] Intellectual property concerns were also noted by the British government.[71] Regrettably, the cost data provided in support of many of the Mott MacDonald arguments was heavily reliant on estimates, and the report admitted their cost data "needs to be tested."[72] As a result, this study was not used to derive the 'made in Canada' premium.

Of greater relevance is the Industry Canada report's detailed examination of warship building policies in Europe. It found that "all other NATO countries have a variation of directed procurement as their approach, with generally only one yard positioned to undertake the building of warships or coast guard vessels."[73] Under a "directed procurement" model, the government directs what ships will be built where without bidding or competition – much as is now done under the NSS.

The study also found that UK, Spain, France, and Denmark directly intervened to both ensure their naval requirements were met and to "guarantee the future of domestic shipbuilding."[74] Moreover, their respective governments rationalized to a single shipbuilding firm each for warship work.[75] Further, the

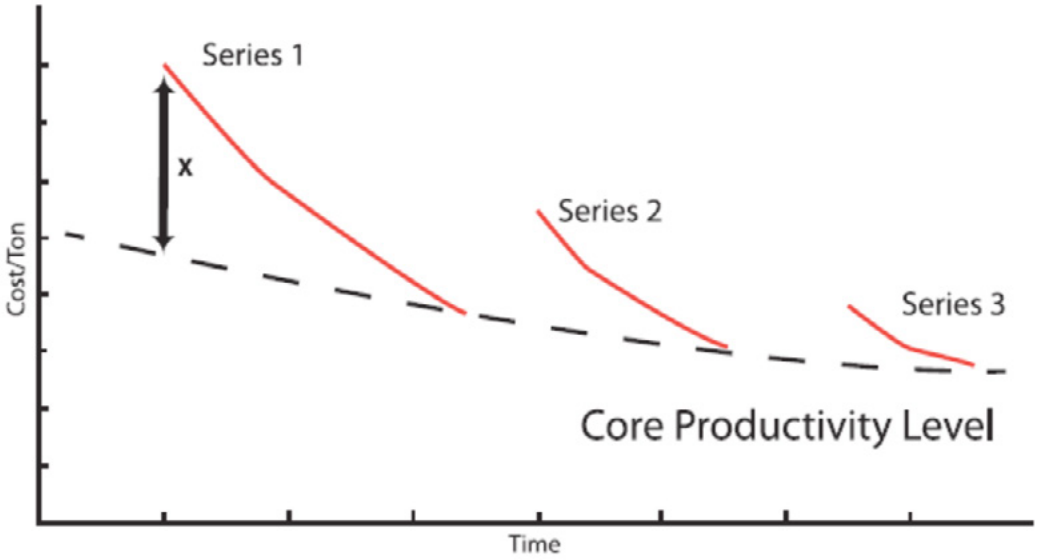
UK guaranteed its sole builder a fixed revenue stream while the Dutch pledged work and actively managed ship construction work flow to maintain the industry.[76] In Spain, the government owns the sole remaining warship building yard – Navantia. With these levels of government intervention, it is not surprising that the report concluded: "If Canada pursues a competitive (inside Canada) procurement strategy it will be unique within NATO."[77]

Significantly, the Industry Canada study also validated the RAND finding that labor rates and shipyard efficiency are the driving factors behind different shipyard costs.[78] In all the European yards, save one, it found few dramatic price differences between them, despite often quite different organizational concepts – assumedly because of relatively uniform pan-European labour costs.[79] The Danish yards were apparently cheaper by a small margin, but the report also noted that for the Danish Thetis-class ocean patrol ship the "Price does not include weapons or equipment." Similar omissions were noted in the data for the Danish Absalon -class support ship and the Knud Rasmussen-class offshore patrol ship.[80]

Canada's Parliament Budget Officer (PBO) also contributed important studies on warship costs, but these focused more on the adequacy of the overall government funding assigned to first, the Joint Support Ship (JSS) and then, the Arctic Offshore Patrol Ship (AOPS). They relied heavily on the parametric analysis in both reports, and this, again, did not provide the author any opportunity to establish potential 'made in Canada' premiums. Moreover, the PBO authors did not seek to determine such premiums. They did experience the usual data problems. Within the report on the AOPS, they found "no reliable cost information available" for any foreign equivalent, including the Norwegian's Svalbard-class or the Danish Thetis- or Knud Rasmussen-class.[81] This necessarily leads one to ask how the significantly less expert Canadian media could have still predicted a Canadian AOPS could cost seven times what the Danish were paying for their Arctic patrol ship.[82]

Certainly, industry, if not government, is starting to push back over media criticism of Canadian ship costs. Irving Shipbuilding responded quickly to allegations its AOPS design costs exceeded the Danish or Norwegian purchase price for their patrol vessels by arguing the media had provided a "classic case of comparing apples to oranges."[83] While the CBC report that provoked this had indeed done so, neither Irving nor the government provided cost data to counter these claims. It had been requested. One must also accept that early on in a ship's construction the cost data will not precise and when bids are coming in on the warship's design competitive secrecy will be called for. However, after a contract is let and construction has begun, cost data – optimally in sail-away cost format – needs to be provided.[84] Moreover, we now have a series of solid studies that make clear cost data from some countries and for some ships is unreliable. This was particularly the case for the PBO effort to get Danish and Norwegian patrol vessel costs. Those responding to these types of apples or oranges comparisons should not be reticent in noting

Figure 4 - The Effect of Learning on Ship Costs



Source: John Craggs, Damien Bloor, Brian Tanner, and Hamish Bullen, "Naval Compensated Gross Tonnage Coefficients and Shipyard Learning" *Journal of Ship Production*, 20, 2 (May 2004), p. 111, Figure 1, as cited in David Peer, "Learning Curves," *Canadian Naval Review* - Making Waves 9, 1 (2013): p. 31.

several well-regarded studies found their data unreliable.

However, the PBO study of the Joint Support Ship found it could rely on historical cost data from US, British, Dutch, Spanish, and German replenishment ships for its parametric analysis. In that isolating 'made in Canada' premiums was not the PBO's objective here either, this study could not put the data to use. This was in spite of the fact that the PBO was able to set the JSS' production cost at $232 million and that this figure certainly seemed to be in the same range as its foreign-built counterparts.[85]

The very high development costs in comparison to the modest production costs certainly hint at the potential inefficiencies of short production runs for ships like the Joint Support Ship.[86] As has been shown, ship construction follows a learning curve and peak efficiency is arrived at the fourth to six ship. However, David Peer has recently argued that under the NSS a yard will accrue efficiency gains as it moves from ship contract to contract even though the ship designs are different.[87] Figure 4 shows this with "X" denoting the very high "first of class productivity penalty" at construction start, and "X" can be as high as 44 percent for a warship like the CPF.[88] However, for less dense and less complex vessels such as merchant ships and potentially tankers, the first of class productivity penalty can fall to 10 percent, and given the often short production runs in the non-combat work assigned to Seaspan, that is potentially encouraging.[89] Moreover, Peer argues that "[s]hipyards that commit to use best industry practices will approach core productivity faster and after fewer ships."[90] It has been shown that the Canadian yards are committed to those best practices and will only gain further contracts if they maintain them.

Among those best practices, the current NSS focus on "design then build" has significant potential to indeed lower that sharp initial learning penalty and to keep doing so. In addition, Timothy Choi has compared the reformed Canadian shipyards under the NSS to South Korea's successful ones and argued: "In sum, the radical bottom-up reconstruction of Canadian shipyards holds the promise of not just decreased costs for Canada's ships, but also the possibility of competing for foreign orders and decades of continual work."[91]

Regrettably, the media-led debate in Canada has generated a view that Canadian shipbuilding costs are so high, with costs incorrectly tagged at five to eight times the Canadian rate, our ability to export ships is rarely discussed. Yet Forecast International reported that in 1994 that Irving's Canadian Patrol Frigate had won the Saudi Arabian Navy's competition to provide its next frigate.[92] It seems only the last minute intervention of the Saudi King reversed this decision in favor of the French Lafayette-class after a visit by France's President. Intriguingly, no Prime Minister or, in fact, Minister had gone out from Canada to support a CPF sale.[93]

That failure did not foreclose other export options for Canadian industry. Based on their ability to showcase highly advanced Canadian technology within the Canadian Patrol Frigate, firms like OSI Maritime Systems have sold over 500 of their ship and submarine integrated navigation systems to over twenty navies. They dominate the world market.[94] Similarly, the machinery control systems produced by L-3 MAPPS, formerly CAE Marine Systems, have generated over $3.2 billion in sales and are fitted in the most advanced warships in the world, including the USS *Zumwalt* and the latest British aircraft carriers. The secure communications systems produced by DRS Technologies are now installed in US aircraft carriers, cruisers, and destroyers as well as the ships of the Japanese, Dutch, Australian, New Zealand, and South Korean navies. Indal Technology's (now Curtiss-Wright) "bear trap" style helicopter hauldown systems have captured 75 percent of the worldwide warship market with over 270 systems fitted.[95] Lockheed Martin, as prime contractor, won the competition to provide the midlife update to the New Zealand's frigates for $180 million.[96] Today, there is increasing concern over the ability of some nations to ensure the cyber integrity of their supply chain, and here Canada appears to be one of the more stringent. With its reformed yards, a history of successful warships and competitive costs, Canada should therefore not automatically count itself out of the warship export business, acknowledging our current strong suit lies in the export of advanced maritime systems.

Conclusion

In Australia, the RAND report ultimately argued their government could reduce their domestic shipbuilding premium from 30-40 percent to 20 percent if it moved to a continuous shipbuilding strategy and in-

troduced a form of continuous improvement similar to that mandated in the Canadian NSS process. The RAND report also assessed that the long-term allocation of government warship work would encourage the needed investments in shipyard and worker upgrading also seen here. A year later, the Australian government followed these recommendations and assigned frigate and patrol ship building contracts worth A$40 billion to ensure a continuous series of work would follow the AWD project. As the Canadian NSS process had started that same path six years earlier, it again seems difficult to accept our own building premium could exceed their targeted 20 percent rating.

This should not be a cause for immediate celebration in Canada. To do so would demonstrate a lack of understanding of domestic, and particularly Canadian domestic shipbuilding premiums. As seen, the 'made in Canada' premium is not just the result of manufacturing efficiencies or the lack thereof. Rather, the Canadian premium also contains an administrative or bureaucratic component that includes costs no one else does and a political premium where work was distributed to multiple yards for regional benefits. These latter two factors can double a Canadian ship's costs. In this regard the National Shipbuilding Strategy has eliminated the regional distribution problem in this mix while also putting in place a system that would ensure far greater shipyard efficiency. Yet, the recent acceptance of MIL Davies' proposal for converting and leasing an interim supply ship suggests governments could be under regular and sustained pressure to revert to the inefficient regional benefits model.

The Canadian bureaucratic premium for shipbuilding is less easily reduced. Government policies mandate we pay sales tax on our ships where few of our allies do, and include project management salaries and pensions in our ship budgets that NATO rules do not accept. Further, the CPF provided twenty times the sparing levels the US Navy does and at least five times what NATO allocates. These unique Canadian approaches to ship costs were not randomly derived. Rather, most were justifiable responses to earlier procurement problems. Further, paying for project management salaries from project funds was probably the only way one could generate the needed government oversight experience quickly. Given our urgent need for that expertise within the National Shipbuilding Strategy, cutting that source of funding today would be foolhardy indeed. On the other hand, as we are now in a 30-year continuous shipbuilding process, it may be time to move to a more 'continuous' – that is more permanent – staffing model to manage the NSS' projects as well.

Reform is needed as these purely administrative costs added billions of dollars to the CPF's final costs and passed ammunition to those critics who complain about high Canadian ship costs relative to other counties. Given the difficulty the major studies have had getting quality international ship cost data combined with the government's reluctance to provide such Canadian data, it is not hard to see reporters getting caught in 'apples to orange' cost mix-ups. Earlier, the Chief of Review Services report provided a

refreshing counter to high cost claims with its 'apple to apple' comparison using NATO's precisely defined sail-away cost as the metric. Today "sail-away cost" is still ideal for cross-national comparisons because it includes all construction, modest spares, and basic project management, while cutting out the ship design and administrative elements other nations either do not cost or do so confusingly. At the same time, Canada should move, where it can, to align its administrative costing with NATO's standards.

Within the Industry Canada, RAND, DND CRS, and PBO studies, several states seemed to provide researchers with the most difficulty in ascertaining ship costs.[97] These include South Korea, and to a lesser extent Denmark, Japan, and Spain. While they have been frequently lauded for their low costs, shipyard efficiency, and skillful use of offshore builds in Denmark's case, it is disconcerting that they were also frequently cited for missing or doubtful ship costs. This reinforces the need for any Canadian comparisons to stick to a standardized metric like sail-away cost and to challenge suppliers to present costs using the same criteria. Further all involved in this, including the media, would be well advised to note the RAND report's comment on costing sources:

> We report values to a precision consistent with the original sources. However, the precision does not always imply the accuracy of the values. This is particularly true for the reported ship costs that one finds in the press or on the Internet.[98]

As seen in the case of Irving Shipbuilding responding to media allegations of high costs, a rapid response with hard sail-away cost data is needed. Moreover, when the opposing foreign cost data comes from one of the states the RAND, PBO, or Industry Canada studies identified as not having consistently reliable data, this too should be noted.

When those cost reporting issues are addressed, the NSS will be able to concentrate on shipbuilding productivity. However, it should also be clear that vigilance is required and Canada will only be able to maintain low national premiums for shipbuilding if it follows the lessons just learned:

- Shipyards building government vessels will only invest in modern facilities and trained workers if there is predictable long-term government work. The NSS needs to maintain at least a 30-year outlook.

- Within that long-term outlook, governments also have a responsibility to ensure their ship needs do not arrive in a 'boom and bust' cycle. Load leveling is needed, otherwise shipyards face gaps and difficulties retaining skilled workers.

- Shipyards, in return, must maintain the drive for efficiency and the government has every right to

monitor this via such successful mechanisms as First Marine International assessments.

- Governments have recognized and must continue to recognize there is no point allowing new, and especially unreformed shipyards into this mix.

- All the ships of one class must be built in one yard and not distributed to provide short-term regional benefits. This can eliminate a shipyards learning curve to greater inefficiency.

While the data suggests the our modest 'made in Canada' premium will continue to result in ship costs "reasonably competitive with other nations," and that our NSS and shipyard practices are efficient, much more analysis must still be done:

- The economic benefits of the NSS are potentially immense and range from the high quality employment for over 1,200-1,500 Canadians a year for 30 years, to the replacement of much of Canada's government fleets, to the establishment of what is essentially a new national industrial capability. Regrettably, the international literature on the actual economic benefits of government shipbuilding is thin and of doubtful value in assessing whether those benefits are being achieved and at what cost. A major study is required.[99]

- The success of the National Shipbuilding Strategy and our modernized shipbuilding industry will be heavily dependent on our ability to establish an effective national supply chain. At the same time, there has been a heavy government focus on using existing foreign ship designs. How these two thrusts can be achieved needs urgent analysis.

- It is not too early to start thinking what build comes after the Canadian Surface Combatant. With no follow-on build identified and the final CSC delivery likely occurring twenty-six years from now, we need to make sure we are not creating the conditions for a third 'boom and bust' cycle.[100]

- Canadians will necessarily question the costs and capability of the CSC and potentially many of the other ships assigned to the NSS. The CRS study of the costs and capabilities of the Canadian ship in relation to its foreign competitors was effective in addressing similar concerns in 1999. One can be safe in assuming another will be needed. However, a report covering the CSC should not be delivered three years after the last ship is built, as happened for the CPF. It should logically commence in mid-program as by that time the learning curve will be shallow and Canadian costs known. Work must begin earlier than that given that the data from foreign builds will still be as has hard to get as today. Meanwhile, smaller scale cost comparisons for the AOPS and JSS might prepare the way.

In examining the need for such extensive analysis, one should very much consider the Australian example. Despite extensive problems in building the Collins-class submarines and the Air Warfare Destroyer, they pressed ahead with their own national shipbuilding strategy. Their proximity to danger does not explain this, as there would be an equally compelling case for buying more quickly delivered warships and submarines from multiple overseas suppliers. Rather, one has to suspect that the extensive analysis of their shipbuilding industry by the RAND Corporation, the Australian National Audit Office, and the Australian Strategic Policy Institute played a key role in accurately presenting the costs and benefits of the 'made in Australia' option. We could do well to match their efforts.

ABOUT THE AUTHOR

Commodore Eric Lerhe *was commissioned in 1972 and from 1973 until 1983 served in the HMCS* Restigouche, Yukon, Fraser, *and* Annapolis. *He then went on to command HMCS* Nipigon *and* Saguenay *between 1987 and 1990. He then served as Director Maritime Force Development and Director NATO Policy in NDHQ. He earned his MA at Dalhousie in 1996 and was promoted to Commodore and appointed Commander Canadian Fleet Pacific in January 2001. In that role he was a Coalition Task Group Commander for the Southern Persian Gulf and Strait of Hormuz sector during the War on Terror in 2002. Cmdre Lerhe retired from the CF in September 2003 and commenced his doctoral studies at Dalhousie. His PhD was awarded in 2012 and his thesis on the sovereignty implications of Canada-US interoperability was published by the Center for Foreign Policy Studies.*

Annex A - Canadian CPF and US FFG-7 Cost and Cost Per Ton Breakdown

This table presents the calculations the author used to independently derive CPF sail-away and project cost. These are ranged against both the CRS calculations and the Congressional and Forecast International costs for the FFG-7. It also shows the cost per ton calculations and the subsequent indexing of the CPF to the FFG-7 baseline of "1" needed to enter CFP data in the costing tables within this study.[101]

Table 10 - CPF and FFG-7 Costs and Cost Per Ton ($C in 1995 CY).

	Refs	Budget $M	Name	Unit Cost $M	Cost Per Ton	Indexed to FFG-7
CRS CPF Costs						
Project Cost	CRS		CPF A	516	.108	-1
Sail-away Cost	CRS		CPF B	424	.089	-21
Author's CPF Project Costs						
Budget	PWGSC/DND Review	9,310				
Less excess spares[102]	"	-822				
Less PMO salaries and benefits	CPF Completion Report[105]	-308				
Less Design[103]	" " " p. 42, 5	-561				
Less Tax	" " " p. 39	-464				
Less Training[104]	" " " p. 46	-112				
Less Insurance	" " " p. 44	-108				
		6,935	CPF C	577	.120	+10%
Author's CPF Sail-away Costs						
Budget	As above	9,310				
Less excess spares[106]		-907				
Shipyard only PMO costs[107]		-749				
Less Design		-561				
Less tax		-464				
Less training		-112				
Less facilities	CPF Completion Rept, p.	-71				
Less Insurance[108]	46	-108				
		6,338	CPF D	528	.111	+2%
FFG-7 Costs						
CRS Project Cost			FFG A	543	.136	
CRS Sail-away Cost			FFG B	396	.098	
Forecast Int'l Low			FFG C	347	.087	
Forecast Int'l High[109]			FFG D	486	.122	
GAO Selected Acq Report[110]			FFG E	319	.080	
GAO (Staralow)[111]			FFG F	522	.131	
Baseline					.109	Baseline

Source: See notes 102-111.

Why items like "salaries," or "excess spares" were subtracted from the CPF's budget cost has been explained earlier and largely follows NATO's costing guidelines. Where there was a difference between NATO's costing conventions and those used by the US government (i.e., the US does not include taxes), I followed the latter as CPF costs were base-lined against the US FFG-7 in both the RAND report and this study.

NOTES

1. Terry Milewski, "Canada's vast shipbuilding plan still at starting line," *CBC News*, 4 May 2015, http://www.cbc.ca/news/politics/canada-s-vast-shipbuilding-plan-still-at-starting-line-1.3058147.

2. J.L. Granatstein, "National interests collide in ship strategy," *Times Colonist*, 1 November 2013, http://www.timescolonist.com/opinion/columnists/j-l-granatstein-national-interests-collide-in-ship-strategy-1.680471#sthash.FhNzagyr.dpuf.

3. Canada, DND, *Chief of Review Services Report on Canadian Patrol Frigate Cost and Capability Comparison* (7050-11-11, 1999), p. 3, http://www.crs-csex.forces.gc.ca/reports-rapports/pdf/1999/70501111-eng.pdf (henceforth "CRS").

4. Murray Brewster, "Canadians won't see price tag for navy frigate replacement until 2019," *CBC News*, 26 May 2016, http://www.cbc.ca/news/politics/warship-cost-contract-signed-1.3601839.

5. Timothy Choi "Boom and Bust: An Opportunity?" *Canadian Naval Review* 9, 4 (2014): pp. 36-37 (emphasis in original).

6. This analysis will not attempt to measure the broader economic benefits of a 'made in Canada' policy, which would entail assessing direct and indirect job creation, and potential "multiplier" or "spillover" effects that accrue from having or establishing an industry like shipbuilding. While two of the studies this analysis relied on for ship costing data considered these broader economic effects, their results were complex and inconclusive. See John Birkler, et al, *Australia's Naval Shipbuilding Enterprise: Preparing for the 21st Century* (Santa Monica, CA: RAND Corporation, 2015) (henceforth "RAND ANSE"); and Mott MacDonald, "Economic Analysis Of National Shipbuilding Procurement Practices – International Comparison Of Ship Construction Costs – Deliverable C" (report prepared for Industry Canada), May 2009 (henceforth "IC"). The report was gained through Access to Information (A-2009-00101) and has been lightly redacted. For a positive view, see CADSI, "Sovereignty, Security and Prosperity – Government Ships –Designed, Built and Supported by Canadian Industry," 1 May 2009, https://www.defenceandsecurity.ca/UserFiles/File/pubs/cadsi-mir.pdf.

7. When dollar figures are used they will be in Canadian 1995 constant year dollars, since that was the metric used in the CRS report. When it conducts cross-national cost comparisons, the paper will adjust for both the historical exchange rate using the "PACIFIC Exchange Rate Service: Foreign Currency Units per 1 Canadian Dollar, 1948-2015" at http://fx.sauder.ubc.ca/etc/CADpages.pdf. and inflation by accessing the Bank of Canada historical "Inflation Calculator" at http://www.bankofcanada.ca/rates/related/inflation-calculator.

8. RAND ANSE. This and the 1999 CRS Report are also the only two public studies that provide detailed international comparisons of warship costs directly applicable to Canada. Both studies also employ similar costing methodology, allowing the author to adjust costs to reach 'apple to apple' comparisons and then extend them to Canada's case.

9. As David Peer has explained, a 'fresh sheet of paper' costing is likely beyond the skill or resources of an independent researcher forcing this necessary reliance on other studies. See his "Estimating the Cost of Naval Ships," *Canadian Naval Review* 8, 2 (Summer 2012).

10. NATO, A*NEP-41(Ed 4) Ship Costing* (NATO Standardization Agency, April 2006), p. 1-1.

11. *ANEP-41*, pp. 4-5. 4-6.

12. CRS, p. 9/3.

13. As some have noted, you do not go shopping for a pickup truck and expect the Ford dealer to provide the $120,000 lifecycle costs of an F150 that would cover the owner's 15 years of fuel, insurance, repairs, and replacement tire costs.

14. Canada, DND, *Canadian Patrol Frigate Project Completion Report* (DGMEPM), Ottawa, 27 July 2005, pp. 47-48 (henceforth "CPF Completion Report").

15. The origins of these reports, their scope, the originating organizations and titles are well laid out at Canada, PWGSC and DND, *Interdepartmental Review of the Canadian Patrol Frigate Project Report on the Contract Management Framework* (Ottawa: 26 March 1999), p. 1-4/48 (henceforth "PWGSC/DND Review").

16. Unfortunately, I was not able to conclusively identify Ship 5 due to a lack of unique identifying features under its listing in CRS Annex A. From that annex it was relatively easy to identify Ship 1 as UK Type 23, Ship 2 as USS Oliver Hazard Perry-class frigate, Ship 4 as the French Lafayette-class, and Ship 7 as Australian Anzac-class.

17. _____, "Warships Forecast, Halifax Class (archived)," (Washington, Forecast International, Aug 2002), p. 4.

18. Anthony Reston, "Seeing The Big Picture," *Naval Forces* XV (November 1994).

19. See CRS, p. A-3/7 wrt "Ship 1."

20. James C. Bussert "Foreign Navies Combat System Dis-Integration," *SIGNAL* (March 2003), p. 1, http://www.afcea.org/content/?q=foreign-navies-combat-system-dis-integration.

21. United States, "Statement of Jerome H. Stolarow – the Navy's FFG-7 Class Frigate Shipbuilding Program, and Other Ship Program Issues," Testimony to US Congress, Joint Economic Committee (Government Accountability Office, 3 January 1979), p. 9, http://archive.gao.gov/f0302/108301.pdf. In 2004, the US Navy eliminated the ship's MK 13 Missile Launcher, its main armament, as a cost cutting measure.

22. CRS, p. A-4/7.

23. The CRS comparison selected western frigates built "during the same timeframe" as the CPF and "still in service with world navies operating in the North Atlantic and Pacific Rim." (pp. 2/10 and 4/10).

24. Here "project cost" is the equivalent to *ANEP-41*'s "program acquisition cost."

25. CRS, p. 10/13. With the exception of the US FFG-7, the majority of the remaining vessels had production runs similar to the CPF.

26. United States, "Selected Acquisition Reports (SAR) Summary Table" (Washington: Department of Defense, 16 November 1987), p. 3, http://www.acq.osd.mil/ara/sar/1987-SEP-SAR-SUMTAB.pdf accessed 15 Mar 2016; United States, "Statement of Jerome H. Stolarow", p. 2; and _____, "Warships Forecast, FFG-7 Oliver Hazard Perry Class (archived)," p. 4.

27. United States, *Transforming the Navy's Surface Combatant Force – A CBO Study* (Washington: Congressional Budget Office, March 2003), p. 81.

28. Email held by author with comments of a former senior USN NAVSEA official. The other half of NAVSEA is charged with maintaining the US Navy's current fleets. See also the NAVSEA's website that states: "With a force of 70,000 civilian, military and contract support personnel, NAVSEA engineers, builds, buys and maintains the Navy's ships and submarines and their combat systems." Of note, the command is currently managing 150 acquisition programmes. See http://www.navsea.navy.mil/WhoWeAre.aspx. It has also been the main driving force behind *ANEP-41*.

29. Canada, *Feasibility of Budget for*

Acquisition of Two Joint Support Ships (Ottawa: Parliamentary Budget Officer, 2013), p. 3, www.pbo-dpb.gc.ca/files/files/JSS_EN.pdf (henceforth "PBO JSS"); Canada, *Budget Analysis for the Acquisition of a Class of Arctic/Offshore Patrol Ships* (Ottawa, PBO, 2014), p. 4, http://www.pbo-dpb.gc.ca/web/default/files/files/files/AOPS_EN.pdf (henceforth "PBO AOPS").

30. I will retain the earlier "Public Works and Government Services Canada" in lieu of the new "Public Services and Procurement Canada" and "Industry Canada" instead of the new "Department of Innovation, Science and Economic Development Canada." This makes it easier to cross reference their reports. Much earlier the Department of Regional Industrial Expansion was merged with the Department of Industry.

31. *ANEP-41*, Definition of project management costs at p. A-21. See also William T. Cooley and Brian C. Ruhm, *A Guide for DoD Program Managers* (Fort Belvoir, Virginia: Defense Acquisition University Press, December 2014), p. 19. It stated: "Note that salaries for military and government personnel are not included in PMA and generally not accounted for in program costs." An unkind observer would also argue project funding for these personnel almost guarantees bloat given the sending department gets on the project payroll without cost to itself.

32. PWGSC/DND, p. 15/48. The $970M (BY) shown at p. 15/48 equals $999M (CY) 1995.

33. United States, *Logistic Concerns over the Navy's Guided Missile Frigate FFG-Seven Class* (Washington, DC: General Accounting Office, Comptroller General, 1981), pp. 27-28.

34. *ANEP-41*, p. A-13.

35. *ANEP-41* allows the inclusion of the various forms of sales tax under its sail-away cost. The result, however, is unevenly applied with the US Federal government enjoying a blanket "immunity" from all state taxes. Further, US Department of Defense acquisitions pay no Federal tax. See email held by author quoting former senior US Naval Systems Command senior official, dated 6 Jun. 2016. However, DND must pay all forms of federal tax and provincial sales tax. Canada, *Policy and Regulations – Finance Chapter 8 - Sales Taxes* (A-FN-105-001/AG-001 8-1) DND, undated, https://www.cfmws.com/en/AboutUs/Library/PoliciesandRegulations/Finance/AFN105/Documents/Chap8_e.pdf.

36. Following NATO rules for sail-away cost, the only element of the non-ship costs shown here one could consider a legitimate "ship" cost – would be the some $196M (BY) in Government Furnished Equipment (ammunition, communications equipment, and weapons systems), which only the government could buy. This would make "ship" costs 49 percent of the budget and non-ship costs 51 percent. See CPF Completion Report, p. 40.

37. Danford Middlemiss and Joel Sokolsky, *Canadian Defence: Decisions and Determinants* (Toronto: Harcourt Brace, 1989), p. 198.

38. This is stated quite clearly at CRS p. 11/13

39. CRS, p. 3.

40. If, on the other hand, one uses the average sail-away cost of the 12 CPF (without the MIL learning curve penalty shown in light blue in Figure 3), the Canadian premium rises from 7 percent to 11 percent against the 7 foreign warships.

41. See CRS, p. B-1/3; PWGSC/DND Review, p. 47/48; and Interview with CRS report author (retired), dated 12 May 2016.

42. PWGSC/DND Review, p. 14/48.

43. From Figure 1 of Moyst Howard and Biman Das, "Factors Affecting Ship Design and Construction Lead Time and Cost," *Journal of Ship Production* 21, 3 (August 2005): p. 186-194. This was provided via David Peer's

assistance.

44. CPF Completion Report, pp. 100-101.

45. PBO AOPS, Table B1, p. 27

46. RAND ANSE, pp. iii-iv.

47. James Cudmore, "Cost to build navy's new warships more than doubles to $30B," *CBC News*, http://www.cbc.ca/news/politics/nsps-naval-ship-procurement-costs-1.3345435.

48. RAND ANSE, pp. 103, 109, 115, 118, and 121. The RAND report found warship cost data for all three nations were "less certain," and noted "We are not sure all costs are captured" with regard to South Korea and Japan. In the case of the former, the RAND study admitted it could not get government costing data and had to rely on industry journals. Its concluding comment noted these three countries all had "much lower" costs but "what we cannot say is whether this is an intrinsic difference (they do produce ships for lower costs) or whether the costs are not complete."

49. RAND ANSE, p. 104, 106. They assess labour costs amount to 40 percent of a warship price with "equipment" and "material" each at 30 percent. Timothy Choi provides similar data in his "The Cost of 21st Century Shipbuilding: Lessons for Canada from the Littoral Combat Ship Program," *Canadian Naval Review* 8, 4, (Winter 2013): p. 25.

50. RAND ANSE, p. 104, 106.

51. IC, p. 000097 (using the doc's master numbering,) and at Deliverable C, p. B-3.

52. RAND ANSE, p. 109.

53. Australia, "Audit Report No.22 2013–14 - Performance Audit Air Warfare Destroyer Program" (Canberra, Australian National Audit Office, March 2014), p. 223 (henceforth "ANAO").

54. The diagram at p. 228 of the ANAO report shows the disrupted assigning of modules to shipyards and weak resulting opportunities to learn as a result of the reassigning of BAE's module work.

55. ANAO, p. 211.

56. Ibid. Caution is needed here as expert advice has suggested the initial introduction of 3-D computer design tools can be fraught with, for example, data exchange problems with other parts of a shipyard's computer systems.

57. Ibid., p. 27, 52.

58. Ibid., p. 254, 255.

59. Ibid., p. 255.

60. Ibid., p. 257.

61. David Wroe, "Defence Minister doesn't trust Australian shipbuilder to make 'a canoe,'" *Sydney Morning Herald*, 26 November 2014, http://www.smh.com.au/federal-politics/political-news/defence-minister-doesnt-trust-australian-shipbuilder-to-make-a-canoe-20141125-11tqv7.html#ixzz3zEh2CAbA.

62. Tom Ring, "The National Shipbuilding Procurement Strategy: How Did We Get to Where We are Now?" *Policy Update* (Canadian Global Affairs Institute, March 2016), pp. 4, 9.

63. Ibid., pp. 4, 5.

64. Not even FMI pushes for a 100 percent complete design before construction. A yard strives for this, but there is a recognition workforces cannot remain idle as the last details are entered into the design model. Further, actual ship assembly may reveal better or more efficient steps that need to be incorporated into the design.

65. Some caution is needed here. Although Seaspan's NSS ships will see much final outfitting done at the Victoria yard, the vast bulk of new construction will be in their Vancouver yard. In contrast, the Halifax-class modernization was done wholly in the Victoria yard.

66. See Annex A for the author's supporting cost calculations.

67. For those wishing to begin verification, a good place to start is

in Annex A. There, I provide the calculations I used to derive the base costs of CPF and then compare these to the CRS data. For the RAND data tables I provided the online sources that will allow a researcher to draw and then input the Canadian data and then array it against the RAND figures.

68. IC, p. 000007, Overarching Report, page-2; and p. 000018, Overarching Report p. 4-1.

69. Email held by author from ISI staff member, 2 July 2016; and IC, p. 000045, Deliverable A, p. 21.

70. IC, p. 0000038, Deliverable A, p 14. This recognizes that with internationally sourced weapon systems one will always have to go back to the manufacturers for some spares. However, the assumption that a Canadian ship purchase can rely on the sparing organization of the selling nation's shipyard or navy is fraught. When the UK necessarily abandoned the supply support for the Upholder-class, Canada apparently had to manufacture 'from scratch' such complex articles as snorkel heads. On the other hand, the CPF was purchased with over 30 years of marine engineering spares.

71. Ibid.

72. IC, p. 000047, Deliverable A, p. 23.

73. IC, p. 000075, Deliverable B, p. 2-4.

74. IC p, 000009, Overarching Report, p. 4-2.

75. IC, p. 000016, Overarching Report, p. 2-5.

76. IC, p. 000102, Deliverable C. p. 4-3

77. IC, p. 000019, Deliverable B, p. 4-2,

78. IC, p. 000097, Deliverable C, p. B-3.

79. IC, p. 000094, Deliverable C, S-1.

80. IC, p. 000106-109, Deliverable C, A-1 to A-4. The Danish have successfully transferred some weapons and equipment from older to newer ships and that may explain a small part of this omission. However, given these categories can make up 60 percent of a warship's costs, it is unlikely such transfers justified the complete elimination of these categories from their costs data. The Mott MacDonald analysis certainly did not seem to accept such a blanket elimination. Further, the often quoted example of the UK recently going to offshore yards for its MARS tankers for cost reasons is weakened by the IC report, which notes at that time the "lack of capacity in the few UK yards that could build ships up to that size" compounded by pressure to acquire the ships quickly. See IC p. 000118, Deliverable C, p. B-9.

81. PBO JSS, pp. 11-12.

82. Milewski, "Canada's vast shipbuilding plan."

83. _____"Irving says ship contract comparisons 'apples and oranges,'" *CBC News*, 6 May 2013, http://www.cbc.ca/news/politics/irving-says-ship-contract-comparisons-apples-and-oranges-1.1346574.

84. A reviewer of this paper noted that this can be a challenge as industry will tend to hold that information closely unless required by contract. It was also noted that the US is still able to get that data, assumedly because they write their contracts accordingly.

85. The PBO-derived production cost of $232 million for the Canadian-made JSS – at page 15 and the bottom of table 2.7 (Activity Name by Phase Results) at PBO JSS, p. 16 – is within the range of foreign-built supply ship costs shown in their Table – 2.4 (Normalized Data) at p. 13.

86. Ibid, table 2.7, p. 14.

87. David Peer, "Learning Curves," *Canadian Naval Review* - Making Waves 9, 1, (2013): p. 31.

88. Ibid, p. 32.

89. Some caution is needed here as several of the ships assigned to Seaspan, like the Offshore Fish-

eries Science Vessel, are relatively more complex.

90. David Peer, "Learning Curves, p. 33.

91. Choi, "Boom and Bust," p. 37.

92. _____,"Warships Forecast, Halifax Class (archive)," p. 9. The report also mentioned Belgium was a "possible purchaser."

93. Alongside the more recent controversy over the sale of Canadian Light Armoured Vehicles to Saudi Arabia, this suggest that, despite Canada - unlike other states and despite having export opportunities - lacks a political culture of championing its arms sales. With the original CPF sale, there have also been allegations this was as much due to the Irving firm not wishing government involvement in the sale as it was due to a political reticence. In addition complications and delays in gaining US acceptance of the sale of critical US-made systems in the CPF (Air Search Radar, Towed Array) may have contributed. These were likely related to the US International Trade in Arms Regulations (ITAR) that seek to control the release of US technology. With the later Halifax Class Modernization Project, the Canadian government sought non-US equipment for some systems in order to ensure freedom from ITAR-induced delays or, potentially, its limiting of future Canadian exports. See David Pugliese, "Navy says no to buying American U.S. restrictions on technology can lead to delays," *Ottawa Citizen* 25 January, 2010, http://web.archive.org/web/20121108045439/http://www.canada.com/business/Navy+says+buying+American/2480208/story.html.

94. Email from Ian Parker held by author dated 29 March 2016, which contained the results of his canvassing of Canadian industry.

95. Janet Thorsteinson, "Canadian Naval Technology Earns Global Sales: In the Beginning was the Canadian Patrol Frigate," *Canadian Naval Review* 5, 1 (Spring 2009): pp. 25-26.

96. Carla Wilson, "Victoria Shipyards frigate work attracts global attention," *Times Colonist*, 13 January 2015, http://www.timescolonist.com/business/victoria-shipyards-frigate-work-attracts-global-attention-dollars-1.1729951#sthash.DHzModba.dpuf.

97. RAND ANSE has provided: "the cost data that were less certain (e.g., the Japanese, Korean, and Spanish ship costs identified earlier) were different. They were much lower" (p. 121). Further, "The Korean and Japanese vessels [destroyers] are roughly 25 percent to 50 percent less than the US baseline. However, we have the same concerns about the completeness of the data as we did for the Korean frigate. We are not certain that all costs are captured" (p. 120). More: "However, there is some question about the inclusiveness of the Spanish costs, and discussions between the White Paper team and the Australian LHD program office suggest that Spanish LHD costs include only the direct shipbuilding costs and not such other costs as logistics support and program management" (p. 120). See also their comments on the difficulty of getting Korean data (p. 103), their inability to get government costing data from South Korea or Spain (p. 109), incomplete data availability for Spanish, Korean and Japanese ships (p. 115), and a lack of authoritative sources for Korean frigate costs (p. 118). Cited earlier were the PBO's difficulty in getting "reliable" Danish and Norwegian cost data for their patrols ships, and Industry Canada (via Mott MacDonald) with regard to Danish warship cost information not including "weapons or equipment."

98. RAND ANSE, p. 102-103.

99. Both the RAND ANSE and the Mott MacDonald briefly attempted this with inconclusive results. See also the CADSI

"Sovereignty, Security and Prosperity" report noted earlier. A far more complete review of the benefits has been undertaken in Australia, and the work of the work of the Australian Strategic Policy Institute would be a good place to start. See Andrew Davies and Mark Thomson, "An enterprise-level naval shipbuilding plan," *Strategic Insights* (ASPI, July 2015), https://www.aspi.org.au/publications/an-enterprise-level-naval-shipbuilding-plan/SI93_shipbuilding.pdf.

100. One has less concern for the long range work on non-combat ships in Seaspan. A rough assessment of the Coast Guard's demand seems to indicate the NSS has been allocated but 15 of the 27 larger vessels needed.

101. The differences between the figures and those I presented in my earlier work on this topic (Eric Lerhe, "Is There a 'Made in Canada' Premium for Building Warships?" *Canadian Naval Review* 12, 1 [2016)]: pp. 31-35) reflect my recent receipt of the more precise cost data contained in the CPF Completion Report. Even with this data, I was not able to fully duplicate the CRS costing despite the generous assistance they provided me, noting their work was done 17 years earlier.

102. This reduced the 10 and 30 year spares provisions for the CPF to NATO's 2 year standard.

103. Design costs were excluded from Project Costs to match other states' practices (specifically so in the US case). These are always excluded from sail-away costs according to NATO rules. CPF design costs include $135M noted specifically for design, plus $148 million for systems integration, (identified in the PWGSC/DND report at p. 13/48 and *ANEP-41* considers integration as part of design costs) as is software at $278M (CPF Project Report, p. 38).

104. Under NATO *ANEP-41* training costs are lifecycle costs.

105. CPF Completion Report, pp. 39, 46. See also PWGSC/DND Report, Figure 2 at p. 15/48.

106. This reduced the CFP's spares to the US and NATO equivalent of onboard spares. FFG-7 data was used.

107. In accordance with *ANEP-41*, the only project management costs within sail-away costs are actual shipyard PMO costs less salaries and pensions. See *ANEP-41*, p. 4-5.

108. The government of the day insisted on a 'no risk' posture for the CPF Project. As a result the Marine Floor of Lloyds of London underwrote the project for a premium of $108 million. See CPF Completion Report, p. 44. I can indentify no other country that does this. This is certainly not an identified costing component within *ANEP-41*.

109. The significant variation in FFG-7 costs (an almost doubling of unit costs in some studies) reflects a decision to lengthen the latter ships to provide a larger flight deck for a new helicopter and to also provide a towed array and tactical data system. Even the US GAO offers two unit costs for the FFG-7 – one valued at C$319M and another at C$522M (both CY 1995). This is well covered in RAND ANSE (p.112), which used a range of values for this ship as a result. This is also done here, even though it should be clear the later, more expensive FFG-7 is far more comparable to the CPF in capability and equipment fit.

110. United States, Department of Defense, "Selected Acquisition Report - Summary Tables," 30 September 1987, http://www.acq.osd.mil/ara/sar/1987-SEP-SAR-SUMTAB.pdf. It seems likely this, again, was caused by costing two different versions of the FFG-7.

111. United States, "Statement of Jerome H. Stolarow," p. 9. It seems likely this difference in GAO figures was also caused by costing two different versions of the FFG-7.

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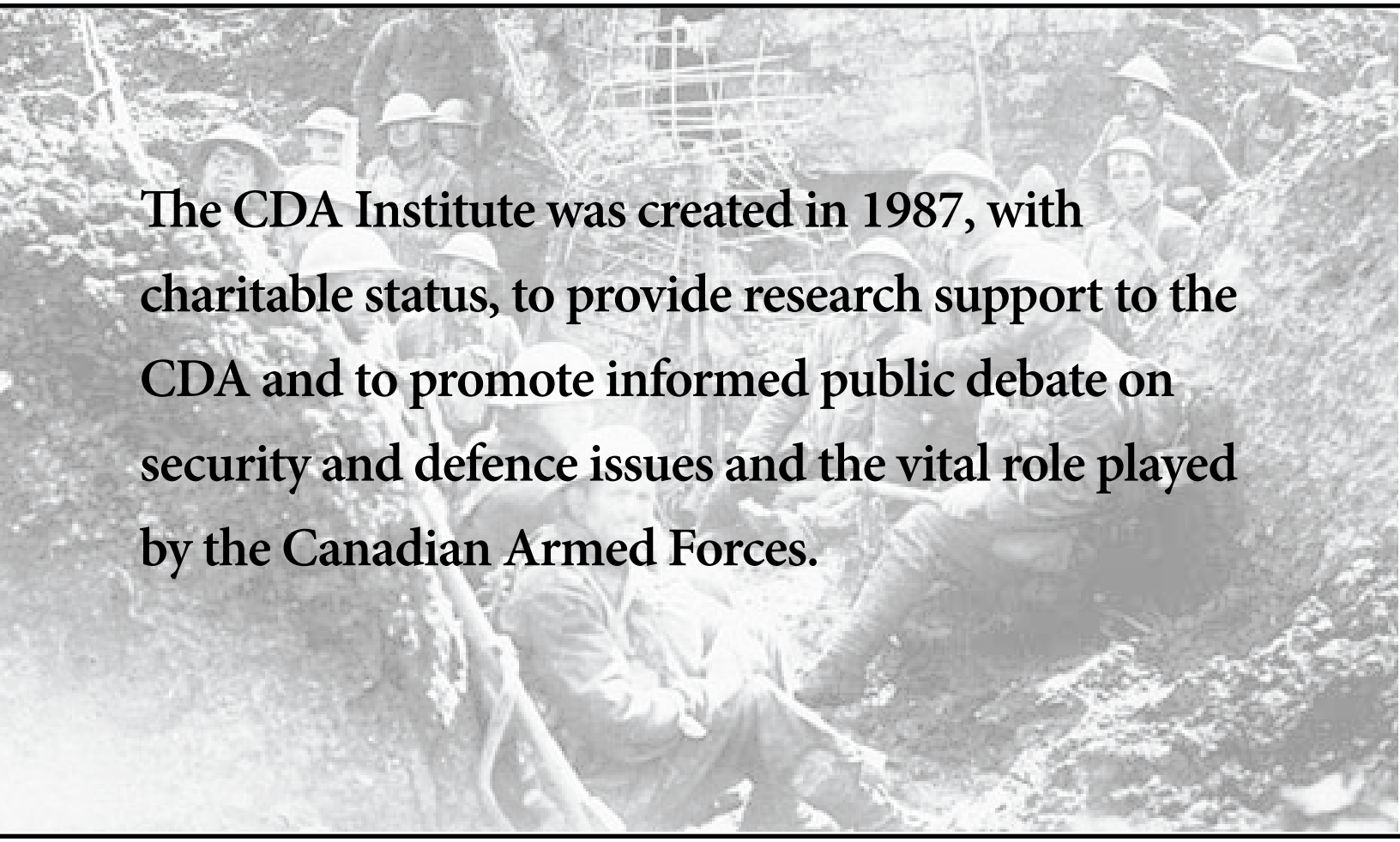

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