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SHIFTING FROM A SHIPBUILDING STRATEGY TO A SHIP SUSTAINMENT STRATEGY: BALANCING ECONOMIC PROSPERITY AND TECHNICAL RISK

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Abstract

In the coming decades the range of maritime threats and challenges that Canada will face is expected to grow. The Arctic is steadily immerging as a greater maritime priority, the proliferation of globalization continues to occupy the world's oceans and many of the actors involved in intrastate or interstate conflict are demonstrating improved capabilities and competencies at sea.[1] To be ready for these impending challenges the Royal Canadian Navy is in dire need of renewal.

The aim of this Directed Research Project was to examine the technical risks to the Royal Canadian Navy that result from imposing economic instruments such as the Defence Procurement Strategy and National Shipbuilding Strategy. Challenges to procurement and sustainment activities were investigated from within Canada as well as from a host of peer nations who are currently implementing extraordinary naval renewal programs.

It was determined that the current approach of solely building vessels in Canada generates significant technical risks which will unfortunately persist throughout the life of the vessels largely due to the already reduced quantity of contracted non-combatant vessels to be built and the expected reduction in combatant ships. A potential solution would be to alter the focus of the shipbuilding strategy in Canada to a focus on ship repair and maintenance. This approach would potentially allow for more ships to be purchased as all options could be considered within the given funding envelope leaving Canadian shipyards responsible for maintenance. Maintaining this enlarged fleet with undoubtedly provide the desired "continuous" labour activities for Canadian shipyards.

[1] Royal Canadian Navy, "*Leadmark 2050: Canada in a New Maritime World*", National Defence, 2016.

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> *Clearly, shipbuilding is not primarily about metal shaping or fabrication. It is a highly complex undertaking that requires specialist skills to integrate modules in the final assembly of a naval vessel in order to satisfy all conditions of the contract. Shipbuilders throughout the world face this challenge but ultimately it is the responsibility of governments, as the sole buyers of naval vessels, to ensure that their shipbuilding projects are managed properly and effectively.*
>
> *- Parliament of Australia*

CHAPTER 1: INTRODUCTION

By 2027 the Royal Canadian Navy (RCN) will look drastically different than it does today. The Arctic Offshore Patrol Ship will be busy ensuring sovereignty of highly contested arctic shipping lanes, the Joint Support Ship will be providing the organic capability of projecting a maritime force and the first Canadian Surface Combatant will be at sea preparing to hoist the mantel as Canada's primary warship; a duty it would assume from the then thirty-plus year *Halifax* class Canadian Patrol Frigate (CPF). While 2027 may seem in the distance, in naval shipbuilding terms ten years it is viewed as only slightly more than a pittance of time. What is proving to be an exciting period of change for the RCN is also proving to be an electrifying time for those involved in the Canadian shipbuilding industry as the task of constructing these vessels, which along with new Canadian Coast Guard ships totals twenty-eight, is the task of the National Shipbuilding Strategy.[2]

[2] Initially released as the National Shipbuilding Procurement Strategy (NSPS), the title was reduced to simply National Shipbuilding Strategy (NSS).

Politically balanced against the strategy's $38 billion dollar budget[3] is the current unemployment rate of 6.6%[4] and the current government's commitment to create jobs.[5] This twenty-five year plus endeavour aims to construct ships while also rejuvenating the Canadian shipbuilding industry. The persistent question remains whether Canada can revive a dormant market sector in warship building and produce an effective warship at a reasonable price.

While the military requirements, in this case naval, are listed as the primary objective of Canada's Defence Procurement Strategy (DPS), the focus has clearly been on creating economic prosperity, perhaps justifiably so. What this does do, however, is lead to an increase in technical risk that appears to be largely disregarded even though the consequences could have lasting misfortunes on the RCN. This research paper will demonstrate that the technology sacrifices created by Canada's Industrial and Technological Benefits (ITB) policy and the National Shipbuilding Strategy (NSS) pose a serious risk that could operationally constrain the RCN for the next forty-plus years. In addition, a shift from a shipbuilding focus to a ship sustainment focus could optimize the desire of continuous Canadian employment in the Naval Engineering Enterprise while also delivering the greatest naval capability.

Outline

To reiterate the thesis above, the intent is to challenge the concept that the current industrial policy and the NSS will pose hardship for the RCN given the anticipated

[3] Martin Auger, "The National Shipbuilding Procurement Strategy: A Five Year Assessment", (Ottawa: Parliament of Canada, 2015) p.10

[4] Statistics Canada, "Canadian Unemployment Rate", last accessed on 30 October 2016, http://www.tradingeconomics.com/canada/unemployment-rate

[5] The Liberal Platform promised 40 000 youth jobs each year for the next three years. To be accomplished through such things as a $10 million investment in trade training which would be directly relatable to many of the labour requirements in the shipbuilding industry. More information can be found at https://www.liberal.ca/realchange/opportunities-for-young-canadians/

increased maritime responsibilities, or even the status quo. Delivering on this thesis will begin by contextualizing defence industrial policy in general terms and discussing how other nations have approached the acquisition of military and more specifically naval equipment in recent history. After summarizing both Canada's defence industrial stance as well as the strategies that have been put into place to renew the RCN and the Canadian Coast Guard the project will highlight some of the unique considerations that are inherent in naval procurement projects.

Next, Chapter 6 will explore areas where the defence industrial policy and the NSS could impact the quality of the products being delivered, the products that must be relied upon for decades by generations of sailors. The next chapter creates a solution that addresses many of the technology shortfalls of the current approach. This solution provides an end state that is as much focussed on the realities of the time as the requirement to develop solutions that serve to deliver and sustain a formidable fleet for decades.

Equally important to describing the outline and reader expectations for the report is establishing what will not be included in the scope of the project. As the focus of this report is on the technical aspects that are being impacted by the defence industrial decisions, the scope has been narrowed to only discuss the economics that are directly related to inducing technical risks that manifest themselves in reduced capability. This report has therefore omitted several economic factors such as exchange rates, and monopolies to name a few.[6]

[6] Several of these economic factors are becoming of increasing concern to the shipbuilding and ship repair industry as they serve to create empires which can hinder competition once the aggregate advantage of size becomes too large. More information can be found at David Peer, "Problems with Naval Ship Procurement?", *Canadian Naval Review*, 15 February 2015, last accessed 01 March 2017,

CHAPTER 2: DEFENCE INDUSTRIAL POLICY

Overview

Defence procurement is about acquiring the non-human, physical elements of capability; the inputs needed to form new or to modify/sustain existing elements of military capability.[7] These military capabilities fit into a larger framework that includes other organizations, military members, diplomatic instruments, etc., which together, generate a product known as national security. Defence industrial policy forms part of defence procurement, focusing on the policies, strategies and decisions that determine and influence the outcomes that achieve the level of industrial capability a nation deems it must maintain or strive towards.

This is done through policy elements such as incentives, tariffs or targeted procurements to support economic growth or protect industry from the global marketplace threats. These types of economic levers are known more generally as offsets. According to the World Trade Organization an offset is any condition that "encourages local development or improves a Party's balance-of-payments accounts, such as the use of domestic content, the licensing of technology, investment, counter-trade and similar action or requirement.[8]

While this is arguably the most official definition, in many other cases the term "offset" is reserved for trade agreements with foreign nations or companies. For example, Fevolden and Tvertbraten divide industrial policy into three sub-sets vice only one. The

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http://www.navalreview.ca/2013/02/problems-with-naval-ship-procurement/ as well as KS Subramanian, "How much does a warship cost?", *DNA: Daily News and Analysis*, 24 July 2015, last accessed on 01 March 2017, http://www.dnaindia.com/analysis/column-how-much-does-a-warship-cost-2107525

[7] Stefan Markowski, Peter Hall and Robert Wylie. *Defence Procurement and Industry Policy: A Small Country Perspective.* (New York: Routledge, 2010). p.12

[8] World Trade Organization, "Revised Agreement on Government Procurement", last accessed on 31 October 2016, https://www.wto.org/english/docs_e/legal_e/rev-gpr-94_01_e.htm

first being “discriminatory procurement” which is known as sole-source in Canada, the second is “offset” where they only include counter-trade instruments and finally “cost-share/work-share” which pertain to multi-lateral procurement projects.[9] What these all have in common is that they represent a body of policy and regulation that places resident industries in favourable positions, positions that may not have necessarily existed if it was not for the influence of the industrial policy.

While the main benefit of these defence industrial policies is the preservation of national security[10], it is the secondary benefit of economic prosperity that most often takes center stage, and it is not difficult to see why. National security is a difficult concept to understand and one that is exceedingly difficult to measure performance upon. For example, adding additional military capability through increased resources does not have a linear relationship with the amount of national security that it provides. This makes national security a very difficult product to measure from a business sense, or more importantly a political sense.

The economic benefits on the other hand are much more tangible, more easily understood and as such become a higher priority to a much larger percentage of the voter population. While defence industrial policies appear be a win-win scenario in that they provide benefit to the economy while also meeting national security requirements it can carry many technical disadvantages especially when through life maintenance is considered.

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[9] Arne Fevolden and Kari Tvetbraten, "Defence Industrial Policy: A sound security strategy of an economic fallacy." *Defence Studies* 16, no. 2 (April 2016),p.177

[10] National security is listed as the primary objective of Australian Defence Industry Policy, Norwegian Security and Defence Policy, Canadian Defence Procurement Strategy and UK Defence Industrial Strategy White Paper from 2005.

With this introduction to defence industrial policy it is clear that many strategies exist to achieve the variety of unique outcomes a nation might desire. Instead of detailing the many strategies that could theoretically exist, the next chapter will investigate the defence procurement strategies of select peer nations.

CHAPTER 3: LITERATURE REVIEW

This section will serve to provide some context to the principles of industrial policy defined above. It will do so through the definitions and boundaries that are associated with defence procurement and defence industrial policy. It will highlight the characteristics and peculiarities with defence procurement amongst peer nations as well as delve into the different methods that are employed by nations to enforce these policies. A short review of some specific cases has been included to provide context to these measures. These cases can then be compared against the current Canadian Defence Procurement Strategy that will be outlined in the succeeding section.

Industrial Policy Overviews

Many policy combinations and permutations exist when it comes to building a defence industrial policy. The variation in approaches that nations have implemented should therefore come as no surprise. The generation of these policies is being fuelled by growing security threats manifested in increased focus on national security. In fact, global military spending has increased from US$1.134 trillion in 2001 to US$1.667 trillion in 2016.[11] Recent arms sales statistics demonstrate a similar situation, the total arms sales by the largest one hundred arms-producing companies (excluding China) increased from US$213,920 million n 2002 to US$401,115 million in 2015[12]. In many cases such as Canada, Australia, Norway, the United Kingdom and Italy this also comes at a time where naval forces are in serious need of fleet renewal. These two realities have led to many western nations embarking on some of the largest naval capital acquisitions since

[11] Stockholm International Peace Research Institute, SIPRI Military Expenditure Database, last accessed on 12 March 2017 at https://www.sipri.org/databases/milex Note: values are listed in constant 2014 US dollars.

[12] Stockholm International Peace Research Institute, "SIPRI Arms Industry Database", last accessed on 12 March 2017 at https://www.sipri.org/databases/armsindustry

WWII and in some cases history. This section will demonstrate how peer nations have tailored industrial policies to meet national needs. It was decided to focus on nations who have just recently completed or are actively involved in shipbuilding activities. Hence, Australia, Netherlands, Norway, and the United Kingdom have been included.

While the United States will be often used as metric, their procurement model was not included for specific reasons. The U.S. is certainly unique in the realm of defence procurement, no other western nation compares from a capability standpoint both in terms of advanced technology or size. For example, in 2011 the Department of Defense was comprised of 136 000 military and civilian personnel working in defence procurement,[13] more than the entire Canadian Armed Forces (CAF).[14] In addition, the prominence of the military and military power in the U.S. culture can't be understated as no other western nation supports prioritizing the military like the U.S. For these reasons it was decided that the approach used by the U.S. is not easily relatable to other nations, especially middle powers such as Canada.[15]

General Trends

The primary trend is that modern military forces rely on new and advanced technology to build greater defence capability – they want qualitative efficiency based on

[13] Martin Auger, "Defence Procurement Organizations: A Global Comparison", (Ottawa: Library of Parliament, 2014), p.4

[14] Canadian Armed Forces are currently capped at 68,000 personnel for regular force and 27,000 for the reserve force. More information on personnel force size and the readiness expectations driving this number can be found at: Parliament of Canada, "Government Response to the Report of the Standing Committee on National Defence : The State of Readiness of the Canadian Forces", last accessed on 19 March 2017 at http://www.parl.gc.ca/HousePublications/Publication.aspx?DocId=6074071

[15] Canada is largely considered to be a middle power, between what are known as "great powers" and "minor powers". These categories of power can be seen as a hierarchy of influence or power from an international standpoint. As the power concept is largely comparative and not absolute clear definitions for a middle power do not exist. Conceptually, middle powers are considered as such because they are able to exercise leadership on an international stage but are not considered to be a global hegemon.

advanced technology rather than quantitative forces based on personnel and equipment.[16] This trend has manifested itself in the naval shipbuilding industry in profound ways, such as production volume and cost.

U.S. Secretary of the Navy clearly articulated that the main issue with building warships is that "technology has provided us with extraordinarily capable ships but we cannot afford to buy as many of them as we would like."[17] As the level of technology increases so to does the cost. Financial pressures reduce the number of platforms that can be bought generating diseconomies of scale resulting in increased cost per unit which is often the measure reported in the press. This three-element equation comprised of cost, number of platforms and level of technology will be a reoccurring theme for most navies analyzed in this study.

This reduction in platform numbers and expectation for state of the art technology has led to an environment with few remaining warship designers and integrators who work in the global marketplace. Companies such as BAE, DCNS, Lockheed Martin, General Dynamics and Raytheon, are prevalent in almost all warship procurement projects. Usual practice is for customer nations to award contracts with these companies to design warships who are then partnered with local shipyards to produce them, or they form a consortium with the shipyard during the contracting process. Regardless of the approach taken, the market for complex naval technology is unfortunately small and continuing to diminish. As the market sector reduces, prices have been steadily

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[16] Parliament of Australia, "Current Trends in Naval Shipbuilding", last accessed on 05 November 2016, http://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Foreign_Affairs_Defence_and_Trade/Completed_inquiries/2004-07/shipping/report/c02

[17] Donald Winter, "Sea Air Space Exposition", Washington, 4 April 2006, last accessed on 15 December 2016, http://www.navy.mil/navydata/people/secnav/winter/2006USNL_SeaAirSpaceExposition.pdf

increasing. This has been seen in recent inflation studies where inflation in the domain of naval acquisition has increased between 6.5 and 11 percent annually compared to an average of less than 3 percent for other consumer goods.[18]

These trends are largely inescapable for most nations as seen been the country-by-country analysis below.

Australia

Australia has embarked on the largest regeneration of its navy since the Second World War, anticipating to spend approximately AUS$50 billion (US$ 38.5 billion[19]) through to 2025-2026.[20] This investment will bring in the future submarine fleet with 12 new submarines, the largest defence procurement in the country's history. It will also deliver 9 new anti-submarine warfare frigates and 12 Offshore Patrol Vessels (OPV).[21] Australia is also currently in the build phase of three Air Warfare Destroyers known as the *Hobart* Class. Given the magnitude of the modernization of the Royal Australian Navy, on 4 August 2015, the Government announced a continuous shipbuilding program to include major and minor warships.[22]

According to the most recent Defence White Paper, the construction of these vessels will be used to "transform Australia's shipbuilding industry, generate significant

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[18] Three studies were reviewed, the first being [Kjetil Hove and Tobias Lillekvelland, "Defence Investment Cost Escalation: A Refinement of Concepts and Revised Estimates", Norwegian Defence Research Establishment, (March 2015)], the second being [Ryan Dean, "That Sinking Feeling: Inflation and the National Shipbuilding Procurement Strategy", Conference of Defence Associations Institute last accessed on 16 March 2017 at https://www.cdainstitute.ca/blog/entry/that-sinking-feeling-inflation-and-the-national-shipbuilding-procurement-strategy] and the third [Mark Arena *et al*, "Why Has the Cost of Navy Ships Risen", (RAND Corporation, Santa Monica, 2006) p.15]

[19] Based on a US exchange rate of AUS$ 0.77 listed on 19 March 2017, last accessed on 19 March 2017 at http://www.x-rates.com/table/?from=USD&amount=1

[20] Australia. Department of Defence, "2016 Defence White Paper", (Commonwealth of Australia, 2016)p.86

[21] Australia. Department of Defence, "2016 Defence White Paper at a Glance" last accessed on 09 January 2017 at http://www.defence.gov.au/Whitepaper/AtAGlance/Maritime-Ops.asp

[22] Australia. Government, "2016 Defence White Paper", (Commonwealth of Australia, 2016) p.5

economic growth and sustain Australian jobs over the coming decades."[23] It is clear from this White Paper statement as well as the contents of the partnering 2016 Defence Industry Policy Statement that Australia is committed to a continuous build program involving "construction of our future frigates and offshore patrol vessels in Australia."[24] The most recent contract awarded on 19 December 2016 to DCNS to build the submarines supports these policy instruments as indications are that the submarines will be designed by DCNS, built in Australia with the combat systems sourced from the United States.[25]

This shipbuilding strategy has not gone without opposition with the *Hobart* class used as evidence. The *Hobart* class has received much criticism due to construction delays and cost overruns to the tune of AUS $870 million and 30 months.[26] Mathias Corman, the Australian Finance Minister, was quite clear in his statement that "We can't ignore the fact that these ships are costing $3 billion a ship when equivalent ships in other parts of the world would have cost us $1 billion a ship."[27] He is referring to the fact that the design was based largely upon the Navantia designed F-100 frigate which were delivered to Spain and Norway at a cost of just over US$1 billion.[28,29] Many of these

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[23] *Ibid*., p. 21

[24] Australia. Government, "2016 Defence White Paper", (Commonwealth of Australia, 2016) p.113

[25] Charis Chang, "Announcement on Australia's new submarines", *News.com.au,* 26 April 2016, last accessed on 10 April 2017 at, http://www.news.com.au/technology/innovation/announcement-on-australias-new-submarines/news-story/dfebfedc713a0335a3c079c9e3adb9ae

[26] Mike Yeo, "Industry Confirms Australia's Hobart Class Destroyers $870 Million Over Budget, Lead Ship 30 Months Late", *USNI News,* 14 October 2015, last accessed on 31 March 2017, https://news.usni.org/2015/10/14/industry-confirms-australias-hobart-class-destroyers-870-million-over-budget-lead-ship-30-months-late

[27] Tony Shepard, "Air Warfare Destroyer Project Dealt Huge Blow Ahead of Saturday Launch of HMCS Hobart in Adelaide", *The Advertiser,* 22 May 2015 last accessed on 24 October 2016 at http://www.adelaidenow.com.au/news/south-australia/air-warfare-destroyer-project-dealt-huge-blow-ahead-of-saturday-launch-of-hmas-hobart-in-adelaide/news-story/58375b4a6876530ebe60cf34ece90e49

[28] Deagel.com, "F100 Alvaro de Bazan", last accessed on 16 April 2017, http://www.deagel.com/Fighting-Ships/F100-Alvaro-de-Bazan_a000423001.aspx. This article lists a unit cost of the Spanish *Alvaro de Bazan* class to be US $789 million.

opponent's criticisms are inflamed by the Defence White Paper itself that states that an Australia shipbuilding program would "lower the costs of acquiring naval vessels"[30], which many believe has not been the case. Australia's program shares many similarities with Canada and therefore provides insight into some of the risks, discussed in later sections, which may emerge with insisting on an in-country shipbuilding program while building warships.

Netherlands

The Netherlands has taken a slightly different stance. They clearly understand the complexity and fluidity of the defence industry. "The defence market as it stands is neither open nor transparent, whether at the European or the global level. There is still no level playing field."[31] The Netherlands clearly view significant investment in the defence industry as a great risk. They view the most significant issue as reconciling resource constraints with increasing military capabilities.[32] For this reason they advocate increased cooperation with other countries as well as other parts of government, industry and knowledge institutions. [33]

As a result, the Dutch shipbuilding model has become uncommon in its mix of local and outsourced manufacturing. While they do not have a formal shipbuilding

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[29] Edward Lundquist, HNoMS Fridtjof Nansen Built to Defend Norway's Rugged Coastline, DefenceMediaNetwork, 25 March 2015, last accessed on 10 April 2017, http://www.defensemedianetwork.com/stories/hnoms-fridtjof-nansen-built-to-defend-norways-rugged-coastline/4/. This article lists the cost for this class to be US $3.5 billion for five frigates and six NH-90 helicopters.

[30] Australia. Government, "2016 Defence White Paper", (Commonwealth of Australia, 2016) p.113

[31] Netherlands. Government, "Netherlands' Defence Industry Strategy", 10 December 2013, p.6

[32] *Ibid.*

[33] *Ibid.*

strategy, they do heavily support Damen Schelde Naval Shipbuilding.[34] This does not mean that all labour is completed in the Netherlands; Damen Schelde Naval Shipbuilding has a subsidiary in Romania called the Galati Shipyard. The Netherlands have made use of this shipyard in recent frigate and Offshore Patrol Ship builds in an effort to reduce shipbuilding costs during the labour intensive period of hull fabrication. For non-combatant vessels hull-fabrication can account for 80% of the cost. [35]

Abandoning the idea of forcing 100 percent nation shipbuilding, the Netherlands are focusing on developing niche capabilities and strengthening ties with what it refers to as the "Triple Helix" which includes government, the defence industry base, and knowledge institutions.[36] This has resulted in Dutch firms becoming increasingly export-oriented and involved in foreign direct investment.[37]

The Netherlands' pivot towards investing in already successful niche companies and fostering relationships both internally and externally is certainly a point to consider for Canada. In considering this approach the fact that the Netherlands are part of a larger European Union industrial policy must be factored into all conclusions.

Norway

Norway presents an interesting naval procurement model with direct links to the Royal Canadian Navy. With a population of 5.2 billion and GDP of US$385 million it is

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[34] The Damen Schelde Naval Shipbuilding facility is the only facility in the Netherlands that remains capable of designing and building naval vessels and complex commercial vessels. More information can be found by visiting http://www.epicos.com/EPCompanyProfileWeb/GeneralInformation.aspx?id=31126

[35] Martin Auger, "The National Shipbuilding Procurement Strategy: A Five Year Assessment", (Ottawa: Parliament of Canada, 2015) p.10

[36] Netherlands. Government, "Netherlands' Defence Industry Strategy", 10 December 2013, p.4

[37] Stefan Markowski, Peter Hall and Robert Wylie. *Defence Procurement and Industry Policy: A Small Country Perspective.* (New York: Routledge, 2010), 309.

significantly smaller than Canada.[38] It is however a nation with a large coastline to defend, including the requirement to operate in the Arctic Ocean. Examining Norway from a naval perspective is beneficial given Canada's similar requirements.

Norway's procurement model is mixed between international procurements and nation built ships. The *Fridtjof Namsen* class frigate was built in Spain, a multi-purpose frigate that has been successfully deployed on several international missions. A total of 5 vessels were procured, at a total cost of $US 2.4 billion dollars, between 2006 and 2009 by Navantia based upon their F-100 frigate design.[39] For the time these vessels were extremely economical considering the capability they provided.[40]

Some of Norway's other national security concerns resulted in tasks that a frigate was not ideally suited to perform and no vessel existed that met their requirements. They therefore constructed two new fleets of ships, the *Skjold* Corvette and the Norwegian Coast Guard Ice Breaker Svalbard. The *Skjold* corvette is an extremely nimble combat ship built to "counter the threat of frigates and destroyers encroaching on the Norwegian coast, especially those of the Russian Navy."[41] A highly advanced missile boat, it is the fastest armed vessel in the world, it is able to destroy targets at a range of 185 km, uses advanced radar absorbing paint and was even designed to project a deceptively small radar cross section that could be mistaken as many types of yachts or barges.[42] In the process these vessels were also of value as they demonstrated Norway's technical

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[38] The World Bank, "Norway Country Data", last accessed on 08 December 2016, http://data.worldbank.org/country/norway

[39] "Frigate Berthed for its Spare Parts", *News in English.no*, 30 September 2013, last accessed on 06 January 2017, http://www.newsinenglish.no/2013/09/30/frigate-berthed-for-spare-parts/

[40] Note that it was the F-100 design that was used by Australian Government as the basis for the *Hobart* Class. While inflation and the variation in some equipment suites would account for a modest increase the cost disparity is noteworthy.

[41] Jacky Chia, "Skjold-class Missile Corvette", *DefenceTalk*, 18 January 2016, last accessed 05 January 2017, http://www.defencetalk.com/skjold-class-missile-corvette-66398/

[42] *Ibid.*

acumen with regards to naval shipbuilding despite the mix of foreign and domestic shipbuilding. Six vessels were designed and built with an impressively low total cost of US$268 million.[43]

Norway also designed and built the Offshore Patrol Ship (OPV) Svalbard for use by the Norwegian Coast Guard. An ice capable OPV with the size and endurance to operate in the Arctic. In 2002, the Norway Coast Guard Vessel (NoCGV) Svalbard was commissioned, with a design and build cost under US $200 million. It is this design that Canada has selected for the *Harry DeWolf* class. After purchasing the mature design from Norway for $5 million and spending an addition $288 million on the design phase, it is estimated that building the ships at Irving Shipyard in Halifax will cost approximately $2.4 billion for between four to six vessels. This cost comparison has raised questions regarding Canada's AOPS program on several occasions.

Norway's acquisitions are consistent with Norway's defence industrial policy that is founded upon the premise that Norway must rely upon other nations. "Our defence industry is niche oriented, and will never be able to cover the full spectrum of products that our defence forces need."[44] Norway has therefore developed a defence industry that is niche oriented, and intends to promote industrial cooperation and access to foreign markets focusing in areas such as air defence systems, missiles and ammunition.

In terms of defence strategy writ large, Norway places great reliance in NATO. The Norwegian Chief of Defence himself stressed that "any credible defence of Norway

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[43] *Ibid.*

[44] Oystein Bo, "Developing Strategic partners for the future", Norwegian Government, last accessed at 10 April 2017, https://www.regjeringen.no/en/aktuelt/oystein-bo-developing-strategic-partnership-for-the-future/id2512512/

will rest on its membership in NATO."[45] With regards to procurement, Norway places great trust in its European Union partners. Norway's submarine replacement program has evolved into an acquisition from either a French or German company with the primary reason being to reduce risk and cost. Norway has decided to build from an existing design and the Minister of Defense has stated that they "will be built by a shipyard that has a long and continuous experience in building submarines."[46]

The impending submarine contract will be Norway's second largest defence contract after the F-35 contract and therefore the Norwegian Government is seeking to increase market access through this procurement. Norway is a clear example of a smaller nation using an offset strategy to increase market penetration. One source indicated that "The Norwegian Parliament expects that a potential future procurement will ensure contracts for Norwegian defence industry equal to the procurement cost, and that these contracts will provide access to the home market of the chosen supplier."[47] As with other nations, Norway is focused on garnering a portion of the increasing export market.

Although Norway shares many of the same naval concerns that Canada does, it does however have on distinct difference in Russia. Norway clearly places defence over industrial policy as they continue to feel threatened by Russia. Canada on the other hand is fortunate enough not to have such a persistent and proximal threat. As a result, Canada

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[45] Norwegian Armed Forces, "Press Release: The Norwegian Chief of Defence presents new Strategic Defence Review", last accessed on 14 December 2016 at https://forsvaret.no/en/newsroom/news-stories/press-release-new-strategic-defence-review

[46] Navy Recognition, "Norway MoD Shortlisted TKMS and DCNS for Ula-class SSK Submarine Replacement", last accessed on 14 December 2016 at http://www.navyrecognition.com/index.php/news/defence-news/2016/april-2016-navy-naval-forces-defense-industry-technology-maritime-security-global-news/3814-norway-mod-shortlisted-tkms-and-dcns-for-ula-class-ssk-submarine-replacement.html

[47] Kjaer, Elisabeth, "Strategic partners for Norway's future submarines" Government of Norway Press Release, last accessed on 15 December 2016, https://www.regjeringen.no/en/aktuelt/strategic-partners-for-norways-future-submarines/id2482241/

has more freedom in determining the balance between national security and economic prosperity.

United Kingdom

It is difficult to analyze naval shipbuilding without discussing the United Kingdom. The U.K. has evolved to become an industrial hub for a great deal of innovation in naval design and shipbuilding. At the end of 2016 around 15,000 people were employed directly in the U.K. shipbuilding and repair industry and 10,000 people indirectly supported through the U.K. supply chain.[48] The U.K. has however taken criticism for its current industrial strategy for warships. Through a business agreement between BAE Systems (BAES) and the Ministry of Defence (MoD), BAES has already been identified as the prime industry partner for warships and submarines.[49] It is this non-competitive relationship that has been blamed for the Royal Navy not having the quantity of platforms it needs to complete the Government's mandate.[50] The U.K. is currently preparing to release a National Shipbuilding Strategy to frame an extremely ambitious build program which includes two new aircraft carriers, *Astute* class submarines, offshore patrol ships, Type 26 Global Combat Ships and the Type 31 General Purpose Frigates. Based upon the recommendations in Sir John Parker's Independent Report[51] it is

[48] Parker, Sir John, "An Independent Report to inform the UK National Shipbuilding Strategy" last accessed on 29 March 2017 at https://www.gov.uk/government/news/parker-review-blueprint-for-a-strong-naval-shipbuilding-sector, p.6

[49] Brooke-Holland, Louisa, "The Royal Navy's new frigates and the National Shipbuilding Strategy: February 2017 Update", U.K. House of Commons, last accessed on 28 March 2017 at researchbriefings.files.parliament.uk/documents/CBP-7737/CBP-7737.pdf, p.3

[50] Parker, Sir John, "An Independent Report to inform the UK National Shipbuilding Strategy" last accessed on 29 March 2017 at https://www.gov.uk/government/news/parker-review-blueprint-for-a-strong-naval-shipbuilding-sector, p.5

[51] Sir John Parker is considered a leading industrialist and business figure in the United Kingdom. He was Director of Airbus Group and Carnival Corporation and has chaired five FTSE 100 companies. He was commissioned by the UK Government to complete an independent study to recommend approaches to acquiring naval vessels.

extremely likely that this shipbuilding strategy's goal will be to transform the U.K. shipbuilding industry to ensure that local shipyards are equipped to meet this future demand, and outsourcing will be by exception. The most publicized aspect of Sir Parker's report was the recommendation that future contracts are more competitive in nature.[52,53]

In addition to the future demand, past procurement issues also justified the Government's requirement for an in-depth study into U.K. shipbuilding. The U.K.'s most recent acquisition, the *Daring* class or Type 45 Destroyer was subject to much scrutiny during build due to cost overages and delays. A budget of £5 billion for six vessels required an additional £1.5 billion to complete the program.[54] The program also took two years longer than scheduled.[55]

The current period of naval renewal around the globe has forced nations to make decisions regarding the approach to getting new platforms. The take-away from the analysis to date has demonstrated the myriad of ways that defence industrial policy can be interwoven into defence acquisition programs. Australia and the United Kingdom for example have blueprinted a very close tie between industry and shipbuilding while other nations such and Norway and the Netherlands are not as rigid in regards to where platforms or components are built. Elements of these approaches will be revisited in subsequent chapters, and should also be kept in mind when considering Canada's stance

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[52] "Naval shipbuilding report calls for BAE competition", *BBC News*, 29 November 2016, last accessed 05 February 2017, http://www.bbc.com/news/uk-scotland-38141477

[53] Tovey, Alan, "Naval Shipbuilding strategy which threatens BAE's monopoly is 'destined for the scrapheap', *The Telegraph*, 3 January 2017, last accessed on 10 February 2017, http://www.telegraph.co.uk/business/2017/01/03/naval-shipbuilding-strategy-threatens-baes-monopoly-destined/

[54] ,"Destroyers 'late and over budget'", *BBC News*, 13 March 2009, last accessed on 10 March 2017, http://news.bbc.co.uk/2/hi/uk_news/7940869.stm

[55] Lewis Page, "MPs slam 'disgraceful' Type 45 destroyers", *The Register*, 23 June 2009 last accessed on 12 April 2017, http://www.theregister.co.uk/2009/06/23/type_45_cpac_slammage/

on supporting the defence industry including the Defence Procurement Strategy (DPS) and the National Shipbuilding Strategy (NSS).

CHAPTER 4: CANADA'S DEFENCE INDUSTRIAL STRATEGY

Shipbuilding in Canada is a political venture as much as it is a means of assuring national security; arguably this has been part of Canada's culture since WWII. Even after the start of the Second World War Canada took careful measures to ensure that shipbuilding companies from all regions were employed. In 1940 a major shipbuilding contract was awarded with great care to ensure that employment was distributed across Canada. British Columbia and Quebec received 72 percent of the $43.5 million contract with 3.6 percent to the Maritimes and 23 percent to yards in the Great Lakes region of Ontario. This was done with the knowledge that the cheapest ships could be build in the Great Lakes with a premium of more than 11 percent to be paid to shipyards in British Columbia.[56] Globalization and naval platform complexity and interoperability have only inflated the problem space as many peer nations are willing to export platform designs and Canada's support to coalition operations makes it very attractive to consider all available options. As a result, Canada has developed a procurement strategy to provide policy guidance to defence acquisition projects.

Defence Procurement Strategy

In 2014, Canada launched the Defence Procurement Strategy. The strategy has three key objectives: delivering the right equipment to the Canadian Armed Forces and the Canadian Coast Guard in a timely manner; leveraging our purchases of defence equipment to create jobs and economic growth in Canada; and streamlining defence

[56] James Pritchard, *A Bridge of Ships: Canadian Shipbuilding during the Second World War*. (Montreal: McGill-Queen's University Press, 2011), 22 and 23

procurement processes.[57] For the most part, the second objective will be accomplished through a revised offset strategy called Canada's Industrial and Technological Benefits (ITB) Policy, which includes a new Value Proposition (VP) framework.[58]

The ITB policy at the highest level is quite simple, companies awarded defence procurement contracts are required to undertake business activities in Canada, equal to the value of the contract.[59] While the ITB policy replaced Canada's Industrial Regional Benefits (IRB) Policy which already included an obligation to undertake business activities in Canada equal to the value of the contract, the addition is the introduction of the Value Proposition (VP) as part of the bid assessment process.

The Value Proposition has instituted a rather large change to the previous policy. The VP requires bidders to compete on the basis of the economic benefits to Canada associated with each bid, to be graded in the bid evaluation process.[60] While the previous policy set out the Canadian content obligations, they were not included as a weighted factor in the bid evaluation process. The new policy places many of these obligations in the bid evaluation process. The VP is also much more than a simple offset strategy. Bidders will be assessed on four factors: how it will endeveaur to generate export business, how it will support Small and Medium Enterprises (SME) in Canada, the regional distribution of work and the blueprint of the direct and indirect ITB commitments in much greater fidelity than before. It is the aggregate of these economic

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[57] Canada. Public Services and Procurement Canada, "Defence Procurement Strategy", last accessed on 15 April 2017, https://www.tpsgc-pwgsc.gc.ca/app-acq/amd-dp/samd-dps/index-eng.html

[58] Canada. Innovation, Science and Economic Development, " ITB Policy: Value Proposition Guide", December 2014, last accessed 17 April 2017, https://www.ic.gc.ca/eic/site/086.nsf/vwapj/VPGuideEng.pdf/$file/VPGuideEng.pdf

[59] *Ibid*., p.3

[60] *Ibid*., p.4

benefits that have been proposed between bidders that are evaluated.

The overall weighting of VP compared to price and technical merit is not fixed in the ITP Guide but generalized to be ten percent of the overall bid. While this number seems quite low this value is in fact significant. For example, consider the following theoretical case of two competing bidders. Two bidders have submitted bid proposals for a contract to provide a piece of military equipment. Each company is well established, and as is common industry practice each maintains awareness of the competition's price. Similarly, each company is well versed in the others product, understanding what technical benefits and shortfalls are inherent in each other's product. Therefore with the bid evaluation criteria provided in advance it is often not difficult to deduce how the competition will score. This leads to bid evaluations which are often very close. The ten percent that is now reserved for Value Proposition differs in that it provides companies with an immense number of possibilities when striving to maximize points.

This means that supporting the Canadian industry could easily become the primary path to success for companies opposed to the previous paradigm that balanced technical merit and cost. It is also conceivable that the lowest technical and financially rated product could be victorious based upon Value Proposition. While the financial impact of adding another element is evident as the weighted factor is simply based upon total cost, the technical impact is not as obvious. The basic requirements are added as mandatory requirements that outline the absolute "must haves" to be included for a bid to be considered compliant. These mandatory requirements are closely reviewed by both PSPC and industry through industry engagement activities to ensure that only the minimum requirements are captured as mandatory to keep the pool of bidders as broad as

possible.[61] As such much of what has come to be expected as a basic operational requirement in terms of minimum in service support requirements, managerial competencies or military capabilities becomes a weighted factor. The inclusion of the VP in the bid evaluation has added another non-technical factor that increases the risk of bids with lower technical ratings being ultimately selected. Focussing on acquiring the "best" equipment is not the intention of the DPS or the ITB policy as they strive to strike a balance and acquire equipment that meets operational requirements under the Treasury Board mission of achieving "value for money".[62] Unfortunately, the aggregation of minimizing the number of mandatory technical requirements and the inception of the VP has dramatically altered discussions surrounding how "value for money" will be measured and what equipment the military will ultimately receive. This example demonstrates that the acquisition of military equipment is not necessarily always of paramount importance compared to economic growth.

National Shipbuilding Strategy

Due to a decline in shipbuilding from the mid-1990's to 2010, the Canadian shipbuilding industry, like many other western nations, was reduced significantly. Many shipyards across the globe including the United States, United Kingdom, Netherlands and

[61] Dave Perry, "Putting the 'Armed' back into the Canadian Armed Forces", CDA Institute in cooperation with the Macdonald-Laurier Institute", Ottawa, 2015. This reference provides an excellent synopsis of trust issues between DND and PSPC. DND claims that PSPC is removed from understanding the demands that the military is faced with and PSPC often blames DND for "gold plating" requirements or being over specific to target a specific supplier. As a result much of what has become the standard level of service or material assurance by DND has been moved to rated criteria in the bid evaluation criteria.

[62] Government of Canada. "Treasury Board of Canada Secretariat mandate", Treasury Board of Canada Secretariat, last accessed on 02 May 2017, https://www.canada.ca/en/treasury-board-secretariat/corporate/mandate.html

even Canada reduced the number of shipyards in operation.[63] As a result the government created the National Shipbuilding Strategy which was a commitment to "create jobs and equip the Royal Canadian Navy and Coast Guard with much-needed vessels."[64] Due to the scale of the procurement planned, a strategy was developed to navigate a continuous build program to avoid the boom and bust cycles of the past.[65]

The NSS was divided into a combat vessel contract and a non-combatant contract. The combat vessel contract, estimated to be over $26 billion, was awarded to Irving Shipyards while Seaspan Inc was awarded the smaller contract, valued at $8 billion to build the non-combatant vessels. Ship refits and maintenance periods along with smaller build contracts were not awarded to specific shipyards. It is worthy to note that submarine procurement was also not included in the NSS.[66]

[63] For the R.N. In 2013 BAE moved all naval shipbuilding to the Clyde due to lack of naval shipbuilding contracts. For more information see - Louisa Brooke-Holland, "The Royal Navy's new Frigates and the National Shipbuilding Strategy: February 2017 Update", House of Commons Library, 2 February 2017, London, p.6. For the U.S. The US military shipbuilding industry has been consolidated into two remaining companies Northrop Grumman (NG) and General Dynamics (GD). For more information see - Industrial College of the Armed Forces, "2004 Shipbuilding Industry Study", last accessed on 13 April 2017, p.4. For the Netherlands. Shipbuilding in the Netherlands, both naval and commercial, has been on a constant decline for decades. At the moment only one remaining shipyard capable of constructing a naval ship remains. For more information see - Wim, Smit, "Naval Shipbuilding in the Netherlands", (Enshede: University of Twente, 2010), p.3.

[64] Pubic Services and Procurement Canada, "About the National Shipbuilding Strategy", last accessed on 13 April 2017, http://www.tpsgc-pwgsc.gc.ca/app-acq/amd-dp/mer-sea/sncn-nss/apropos-about-eng.html

[65] Canada has suffered from boom and bust cycles in naval shipbuilding with significant shipyard renewal required before ships were built in WWII, before the Iroquois class and once again before the Halifax class build programs. Hence its prominence in the NSPS program.

[66] Building submarines is a uniquely complex endeavour that Canada has never attempted. Omitting the submarine replacement program as part of the then NSPS serves as an indication that Canada will likely source replacement submarines from another nation.

CHAPTER 5: NAVAL PROCUREMENT

Two unique aspects must be considered with regards to the importance of the relationship between technology and navies. Firstly, the ocean provides no means of concealment forcing navies to rely on technology disproportionately compared to other environments. Land forces use the terrain for concealment along with assistance from the airforce for rapid access and egress from a battlespace. The airforce rely on speed as well as altitude and cloud cover to provide some level of protection. A warship is unable to rely upon such attributes. Due to the drag through water, vessels have yet to really achieve any large increases in speed since the Second World War making them even greater targets than before considering the modernization in missile and torpedo technologies. As the power increase required is exponential against speed, great increases in power have only delivered marginal increases in speed compared to land and sea vehicles. The ocean also provides very little with regards for concealment of surface ships. This means that ships have not only become relatively slower compared to modern weapon systems but they also have nowhere to hide. As a result of warships being unable to conceal themselves or quickly egress from harms way they are left to protect themselves through an active defence posture, a highly technical form of defence compared to the options available for the air and land forces.

The second consideration that is specific to navies is consequence. Consider that a single torpedo has the ability to destroy an entire ship with few, if any, survivors expected. Each weapon strike becomes strategic as it is capable of consuming over two hundred lives along with sinking a significant fraction of a country's warship fleet for most countries. While the loss of a single life is an atrocity, the land and air components

are structured in a way that loss of life from a single weapon strike is multiple times less dangerous. The shooting down of an airplane or the loss of an armoured vehicle is disparate compared to a warship as they do not carry the same number of warriors. It is for these reasons that western navies are so fixated upon technology to provide defence against attack and the ability to neutralize threats quickly when required.

Even in peacetime, navies rely heavily upon technology for survival. Simply going to sea carries inherent dangers "If the highest aim of a captain were to preserve his ship, he would keep in in port forever."[67] In the vast ocean, technology is relied upon for day-to-day life. While this may seem to be no different to the operation of a merchant ship, several aspects differ. Firstly the cargo is quite different, while merchant ships carry merchandise or bulk cargo, warships carry large quantities of ammunition, have fuel tanks distributed throughout the hull and carry crews numbered in the hundreds opposed to dozens. Due to the time that it takes to transit the world's oceans, a warship departs with a full combat load at all times so the threat of fire or explosion is chronic regardless of the mission. A warship is also required to survive as a lone asset in the vast ocean. Container vessels commonly use what are known as shipping lanes, frequented often by other merchant vessels. Naval ships often find themselves in remote areas including the arctic or higher threat areas that merchant vessels avoid. The HMCS *Protecteur* fire in 2014 provides an unfortunate reminder of these facts. HMCS *Protecteur* was in transit when the back-up generator caused a fire. 279 crew members battled the fire for more

[67] Well known quote by Saint Thomas Acquinas.

than eleven hours before it was fully extinguished.[68] This was all able to happen only 600 kilometers from Pearl Harbor.[69]

Subsequent sections will discuss more specific naval issues dealing with procurement, sustainment and industrial policy. The more doctrinal and inherent aspects discussed above are meant to provide context to those less familiar with naval operations.

[68] James Cudmore, "HMCS Protecteur crew fought engine fire for 11 hours", *CBC News*, 26 March 2016, last accessed 10 December 2016, http://www.cbc.ca/news/politics/hmcs-protecteur-crew-fought-engine-fire-for-11-hours-1.2586636

[69] *Ibid.*

CHAPTER 6: BALANCING TECHNOLOGY AND ECONOMICS

The task of building a warship is complex and therefore difficult to get right. For example, even some of the most advanced shipbuilding nations have experienced design failures such as the U.K.'s decision to adopt a single means of electrical power generation with the Type 45 or *Daring* Class which will be examined in greater detail shortly. The U.S. have also been subject to several technical failings as the recently produced *Zumwalt* class and the Littoral Combat Ship have had no less that five major engineering problems in the last year alone. Building warships, and keeping them modern, is a clearly a venture fraught with immense technical challenges.

Innovation and the resulting technological product refresh rate continues to accelerate in the world with the military being no exception. The cost of acquiring this innovation, along with the constraints and restraints of navigating industrial policy, generates significant technical risks. This chapter will address the more prominent of these risks, namely economy of scale, exportability, research and development, obsolescence and integration.

Economy of Scale

As discussed above, the general trend in western nations is to favour fewer highly advanced vessels over larger quantities with less capability. This of course generates an everlasting conflict when discussing naval capability between technology and number of ships. While the principle of "Fleet in Being"[70] alludes to the doctrinal and combat

[70] The "Fleet in Being" concept is a naval principle which is based upon the principle that naval fleets take years to generate. Therefore having a large capable fleet allows for nations to influence the sea without getting involved in conflict as the lesser fleet will want to keep the fleet intact for future conflicts.

limitations of a small fleet, this trend has compounding affects in the technical domains of building and sustaining a warship.

The reduction in naval platforms have been well documented as of late. The United Kingdom (U.K.), United States (U.S.), Italy and Canada in particular have all articulated that the number of platforms in service have become critically low due to resource constraints. By contrast, Russia and China are expanding their navies at alarming rates.[71] The warship, a navy's greatest instrument in enabling the full spectrum of operations, has been victim to the most acute case of platform reductions. These reductions are of course related to the costs associated with the state of the art weapon systems that are incorporated into the ship.[72]

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[71] For the United Kingdom see - Bernard Jenkin, "Defence Acquistion for the Twenty-first Century", Civitas, (London: Berforts Group Ltd, 2015), 2. and, George Allison, "Fleet size 'way below critical mass'", *UK Defence Journal*, 21 November 2016, last accessed on 12 March 2017, https://ukdefencejournal.org.uk/royal-navy-fleet-size-way-critical-mass/. For the United States see - Sam Grone, "VCNO Moran: Navy is Less Ready Because 'We're too Small'", *USNI News*, 8 February 2017, last accessed on 18 April 2017, https://news.usni.org/2017/02/08/vcno-moran-navy-is-less-ready-because-were-too-small. For Italy see - Peter Bossdorf, "Italy Navy Launches Fleet Renewal", *European Security and Defence Spotlight*, (issue 15, 2015), http://www.mittlerreport.de/fileadmin/user_upload/daten/produkte/esd/ESD_Spotlight_No_15.pdf. For Canada see - Scott Gilmore, "The Sinking of the Canadian Navy", *Maclean's*, 4 February 2015, last accessed on 16 April 2017, http://www.macleans.ca/news/canada/the-sinking-of-the-canadian-navy/ For Russia see - David Axe, US Fears Grow of a 'Newly Awakened' Russian Navy, The Daily Beast, 28 December 2015, last accessed on 10 February 2017, http://www.thedailybeast.com/articles/2015/12/28/u-s-fears-grow-of-a-newly-awakened-russian-navy.html. For China see - Alex Lockie, "How China's navy rapidly modernized to rival the US's", *Business Insider*, 18 June 2016, last accessed on 16 April 2017, http://www.businessinsider.com/how-china-has-modernized-their-navy-2016-6

[72] It is reported that the cost of equipment for a surface combatant is 57% of the total build cost with material being 11% and labour being the remainder. For more information see Mark Arena *et al*, "Why Has the Cost of Navy Ships Risen", (RAND Corporation, Santa Monica, 2006) p.28. The following report indicates that the value of equipment could be even higher with the combat systems equipment alone accounting for 40% of the build cost in general with the Type 45 having a total of 48% attributed to combat systems equipment and 11% for platform equipment such a propulsion engines. Peter Cosgrove *et al*, "Naval Shipbuilding - Australia's $250 billion National Building Opportunity", Defence SA Advisory Board, last accessed on 2 April 2017, http://www.tandfonline.com/doi/abs/10.1080/09733159.2015.1027076?src=recsys&journalCode=rnmf20, p. 12

A current view of shipbuilding amongst western nations shows that the trend will continue as resources remain constrained. Table 1 demonstrates the incongruence between warships planned and warships built or total expected to be built as of 2016.

Table 1: Naval Ships Initially planned by Government Compared to Ship delivered or planned as of 2016

Country	Ship Class	Planned by Government	Delivered / De-scoped as of 2016
United Kingdom[73]	DARING (Type 45)	12	6
United Kingdom[74]	Type 26	13	8
United States[75]	ZUMWALT	12	3
United States[76]	Littoral Combat Ship	52	24
France[77]	FREMM	17	8
Italy[78]	FREMM	10	7
Australia[79]	HOBART	4	3
Germany	F-124	4[80]	3[81]

Source: See Footnotes 73-80

It is this consistent reduction in platforms where the majority of the technology issues can be attributed.[82]

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[73] Thomas Harding, Royal Navy destroyer goes into service without missile system, *The Telegraph*, 23 June 200, last accessed 26 January 2017, http://www.telegraph.co.uk/news/uknews/defence/5604525/Royal-Navy-destroyer-goes-into-service-without-missile-system.html

[74] Richard Norton, Critical fleet of global-combat frigates is indefinitely delayed, *The Guardian*, 20 July 2016, last accessed 01 Feburary 2017, https://www.theguardian.com/uk-news/2016/jul/20/navy-fleet-global-combat-frigates-type-26-indefinitely-delayed-mod-mps-clyde-shipbuilding

[75] Ronald O'Rourke, Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress. (Congressional Research Service, 2016), p. 4

[76] Congressional Budget Office, "Cancel the Littoral Combat Ship Program", last accessed 29 January 2017, https://www.cbo.gov/budget-options/2013/44771

[77] FREMM France, GlobalSecurity.org, last accessed 28 January 2017, http://www.globalsecurity.org/military/world/europe/fremm-france.htm

[78] Tom Kingston, "Italy Reveals Innovations on New Naval Vessels", DefenceNews, last accessed on 29 January 2017, http://www.defensenews.com/story/defense/naval/ships/2016/06/24/italy-navy-vessels-ppa/86338706/

[79] Australian Made Defence, "About the AWD Project". Last accessed on 1 February 2017, http://australianmadedefence.com.au/resources/about-the-awd-project/

[80] The new F 124 class, Die-marine, last accessed on 30 January 2017, http://www.die-marine.de/english/f124.html

[81] Sachen Class (F124) Germany, naval-technology.com, last accessed on 30 January 2017, http://www.naval-technology.com/projects/f124/

[82] It is worthy of note that the countries which focus on constructing warships in country without consortium or consideration for cheaper options have all faced significant reductions in total numbers, where vessels built in a consortium or with cost saving measures through outsourced hulls or modules achieved greater success with regards to number of ships.

It is this building of fewer ships that impacts a nation's shipyard as they are not able to benefit from economies of scale.[83] This idea also holds true for smaller component procurements as well. Many challenges arise for a Small or Medium Enterprise (SME) when plans of supplying components for naval vessels are cut by forty percent as demonstrated by the trend in Table 1.

Compare the model of using organic shipyards to the model that the Netherlands used in the building of the *Holland* class offshore patrol vessel. Seeking to optimize cost and capability while supporting national industry they used a mix of indigenous and international builders. Two of the four vessels were built in the Netherlands while the other two were built in Romania and subsequently fitted out in the Netherlands. The *Holland* class is 108m in length, 16m wide with a displacement of 3,750 tonnes.[84] Canada's AOPS is significantly heavier at 6,440 tonnes but with comparable length and width of 103m and 19m respectfully. In terms of cost, each AOPS will be CAN$383 million (approx. US$288 million)[85] if all six are constructed, or CAN$575 million (approx. US$431 million) if only four are built using the current budget. Comparatively, the total cost for the *Holland* class was €467.8 million[86] (US$495 million) or €116.9 million (US$124.8 million) [87] per unit. While the difference in displacement would justify a nominal increase in cost, the difference in cost of over US$150 million per unit is inordinate. The Dutch model certainly appeared have found a good balance between cost, capability and support to industry. It would therefore not be unrealistic to assume that six

[83] The Canadian Patrol Frigate Program is an example of such an economy of effort. The cost of the first ship was $480 million while the final of the twelve vessel program was $424 million.

[84] DAMEN, "Holland Class Ocean Going Patrol Vessel 3750", last accessed at 10 April 2017, http://products.damen.com/ranges/opv-holland-class/holland-class-ocean-going-patrol-vessel-3750

[85] Based upon exchange rate of 0.75 US to 1 CAN dollar

[86] Naval-Technology.com, "Holland Class Offshore Patrol Vessels, Netherlands", last accessed on 13 December 2016, http://www.naval-technology.com/projects/hollandclasspatrol/

[87] based upon exchange rate of 1 Euro equals 1.06 US dollars

AOPS could be acquired using the same model along with the potential to re-direct funds into other programs.

The economic and technological issues associated with economy of scale are compounded when sustainment is considered. Through life costs of naval platforms can often eclipse the acquisition cost and serve to provide long-term opportunities for companies to maintain business activity. Reducing the number of platforms means reducing the number of components required. This will inevitably result in less spare units being held by the manufacturer as well as increase the risk that some of these companies will not be able to continue to operate for the thirty-plus years required to support the service life.

Program management of sustainment activities are also heavily impacted by economy of scale. Many requirements exist that are independent of a contract's size such as infrastructure and special equipment. In addition, program management teams for such contracts are required to be far more robust than those of civilian programs which can lead to high management overhead ratios with only a few units to maintain. For example, industry is required to manage a myriad of security complexities including Intellectual Property (IP), the Controlled Goods Program, the International Traffic in Arms Regulation (ITAR) policy as well as the physical security measures of entering a naval dockyard and working on a RCN vessel. Management costs will also arise from the management and reporting of the ITB requirements, which would not be substantially different with more platforms to manage. All of this management overhead is required to clear the path so program management staff can concern themselves with the more pragmatic tasks associated with ship repair such as establishing relationships to allow for

emergency repairs to be conducted anywhere around the globe. These activities would not provide any significant additional burden if the number of ships that a company was required to maintain increased. The combined AOPS and JSS In-Service Support (AJISS) contract is indicative of the technical problems that building a Canadian industry capability with such a small fleet generates.

From the onset it was a strategic decision to outsource as much of the maintenance for the JSS and AOPS vessels as possible. The coastal Fleet Maintenance Facilities (FMF) are focused on supporting the *Halifax* and *Victoria* class along with supporting priority operational demands. Due to the relatively small size of each fleet and the fact that vessels are dispersed between the two coasts it was deemed more feasible by Canada, in consultation with industry, for one contract to be awarded for both classes of ship. This decision was based upon the savings at the program management level along with hopes of reducing duplication of repair infrastructure and supply chain activities. The Request for Proposal (RFP) for this single contract is estimated at $5.2 billion if all thirty-five years of the contract are exercised[88], as the trend is for platforms to strive for forty years the total could increase even more. Considering the procurement cost of $2.6 billion for JSS[89] and $3.5 billion for AOPS ($1.2 billion for design and $2.3 billion for construction)[90], the cost of maintaining these vessels will likely surpass the build cost. This case is particularly germane to the economy of scale in sustainment discussion because while the number of ships that will be procured has diminished, the

[88] Canada. Public Works and Government Services Canada, "Tender Notice: AOPS/JSS ISS (W8476-133818/A)", last accessed on 05 November 2017, https://buyandsell.gc.ca/procurement-data/tender-notice/PW-AO-006-23261.

[89] Canada. National Defence and the Canadian Armed Forces, "Joint Support Ship", last accessed on 10 November 2016, http://www.forces.gc.ca/en/business-equipment/joint-support-ship.page

[90] Canada. Government. "Archived – Harper Government Awards Shipbuilding Contract That Supports Jobs Across Canada", last accessed on 07 March 2017, http://news.gc.ca/web/article-en.do?mthd=tp&crtr.page=1&nid=924929

resources set aside to maintain the ships has remained the same. This is indicative that the maintenance costs for eight AOPS and three JSS will likely be only marginally different than the four to six AOPS and two JSS that the RCN will ultimately receive.

The current plan to contract Canadian labour and equipment as much as possible will likely have an adverse affect on units acquired. This diseconomy of scale will no doubt lead to sustainment issues in the future as well as reduced vessels being procured. While it is the intention is to mitigate through export activities, the end result of escalating costs and delays more than likely be fewer vessels produced.

Exportability

A common theme with all the industrial policies that were reviewed was a desire to increase exports. This is of no surprise as they provide many benefits to a nation. Besides the obvious increases in sales and employment, exports provide many other points of value to a navy. They can increase the economies of scale and provide some risk protection through diversification. From a technical standpoint exports often provide additional reason to invest in research and development, can increase efficiency and can support interoperability among nations through common components. These benefits ultimately increase the probability of a company's longevity and subsequent availability of spare parts.

Given that the estimated global defence export market in 2015 was valued over US$ 97 billion[91] and increasing, it is clear why nations wish to have their industries attempt to capture as large a market share as possible. Canada with a total export of

[91] United Kingdom. Trade and Investment, "UK Defence and Security Export Statistics for 2015" Defence and Security Organisation, last accessed on 10 March 2017, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/541330/20160727_-_Official_Statistics_-_UKTI_DSO_Core_Slides_for_2015_-_Final_Version.pdf

military goods and technology amounting to 676 million dollars in 2015 could not be considered a leading exporter when compared to the top nations included in Figure 1. [92]

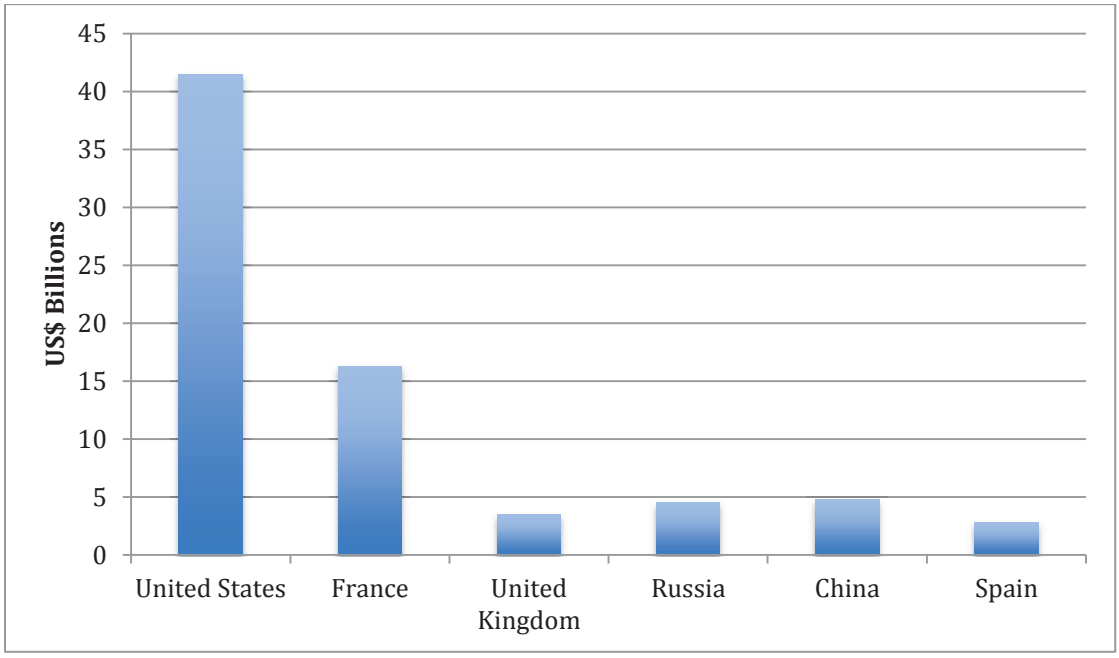

Figure 1: Top Defence Exporters by Country in 2015
Source: Canada. Government. "Report on Exports of Military Goods from Canada 2015", Global Affairs Canada

Another piece of information required for context is the importing countries as it speaks to the type of equipment that will be in demand. It also speaks to a nation's sense of global responsibly. In Canada, military exports are subject to extreme scrutiny. All exports deemed to be military must receive a permit from Global Affairs Canada through the Import and Export Controls Permits Act. Even more rigorous levels of scrutiny exist for specific items such as automatic firearms where companies can only export to countries that appear on the Automatic Firearms Country Control List (AFCCL). This list is regulated by the Export and Imports Permits Act and as of early 2017, only 37

[92] Canada. Government. "Report on Exports of Military Goods from Canada 2015", Global Affairs Canada, (Ottawa: 2016), last accessed on 10 January 2017, http://www.international.gc.ca/controls-controles/report-rapports/mil-2015.aspx?lang=eng

countries are listed as being permitted to receive automatic firearms exports.[93] The list of countries that Canada is able to export to should be considered when examining the largest importing countries included in Figure 2.

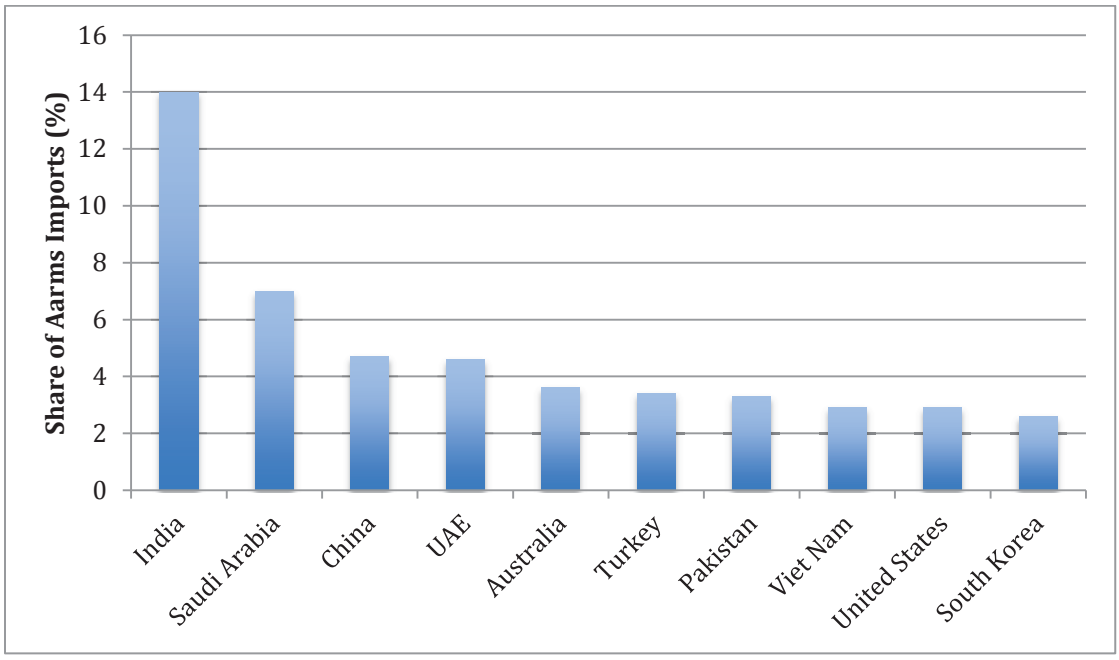

Figure 2: Largest Weapon Importers, 2010-2015
Source: Aude Fleurant *et al*, "Trends in International Arms Transfers, 2015", SIPRI Fact Sheet, February 2016[94]

Even with countries on the approved list the scrutiny of military exports can be immense. Canada's decision to allow the $15 billion purchase of fighting vehicles by Saudi Arabia raised public outcry over how these vehicles may be employed. Freedom House, a human rights watchdog ranked Saudi Arabia as among the "worst of the worst" on human rights.[95] Canada also generated its own Global Affairs report which provided

[93] Government of Canada. Justice Laws Website "Automatic Firearms Country Control List", last accessed 02 March 2017, http://laws-lois.justice.gc.ca/eng/regulations/SOR-91-575/FullText.html
[94] Aude Fleurant *et al*, "Trends in International Arms Transfers, 2015", SIPRI Fact Sheet, February 2016, last accessed on 15 November 2016, http://books.sipri.org/files/FS/SIPRIFS1602.pdf
[95] Steven Chase, "Canada now the second biggest arms exporter to the Middle East, data show", *The Globe and Mail*, 14 June 2016, last modified on 12 July 2016, http://www.theglobeandmail.com/news/politics/canada-now-the-second-biggest-arms-exporter-to-middle-

warnings about the status of human rights in Saudia Arabia.[96] This example was a clear reminder that the ability for a country to buy military equipment only forms a fraction of the decision whether or not a Canadian company is able to enter into a contract.

The analysis above serves to demonstrate that the defence export market writ large is a complex environment, and one where competitiveness is also dependent upon a country's threshold to supply nations who may not share western values.

Maritime Technology Exports

Given the export environment described above, leveraging the export market to grow military technology seems daunting. Honing in on maritime exports, the picture becomes even more risky given the maritime distribution shown in Figure 3.

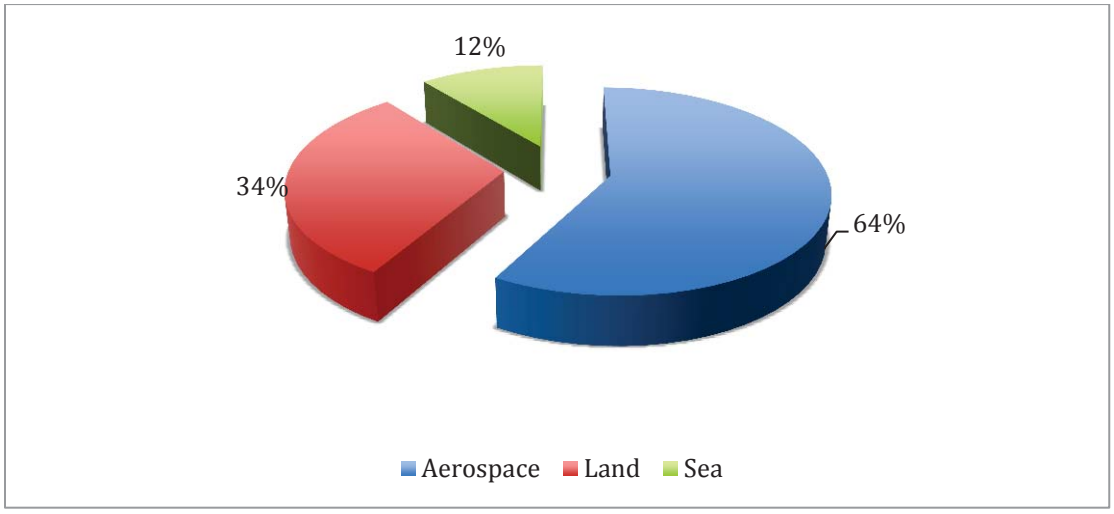

Figure 3: Global Defence Export Markets
Source: United Kingdom. UK Trade and Investment. "UK Defence & Security Export Statistics for 2015"[97]

Each maritime nation is unique and therefore creating a vessel for export is not a straightforward task. In a U.K. report, initiated by the Treasury it was openly stated that

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east-data-show/article30459788/http://www.theglobeandmail.com/news/politics/canada-now-the-second-biggest-arms-exporter-to-middle-east-data-show/article30459788/

[96] *Ibid.*

[97] United Kingdom. UK Trade and Investment. "UK Defence & Security Export Statistics for 2015", last accessed on 01 December 2016, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/541330/20160727_-_Official_Statistics_-_UKTI_DSO_Core_Slides_for_2015_-_Final_Version.pdf

"Naval Ships are not designed to be export friendly"[98], and the bespoke nature of the Type 45 (*Daring* class) is a testament to such a statement. With the future General Purpose Frigate (GPFF) planned for construction in the 2020's, discussions within government took place to determine the value of exportability in an already congested frigate market. The U.K. acknowledged that a technical or capability trade off must occur between what they refer to as the two "ambitions", Admiral Jones, the First Sea Lord in late 2016, believed that for the GPFF to be attractive to the export market a trade-off would occur which would require the GPFF to be at "a slightly lower end of naval operations."[99] While any capability concessions would not be published, it is clear that the GPFF maintained an export focus as the proposed level of technologically advanced equipment pales in comparison to what was included in the Type 45. In fact the UK ultimately decided in the 2015 Strategic Defence and Security Review to separate the original plan for 13 Global Combat Ship into two acquisitions, the Type 26 and the Type 31. This decision was done to allow for the U.K. to keep specific capabilities while also hoping to produce a warship for export as part of the new Exportability Policy. [100] The Type 26 program is clear in its specific focus as a "high-end anti-submarine warfare frigate, and it is deliberately designed to do so." Admiral Sir Philip Jones, the current Sea Lord, continues to state that it will be " noise-quietened and highly effective in

[98] Ewen MacAskill, "Royal Navy stuck with ships 'well beyond sell-by date'", *The Guardian*, 29 November 2016, last accessed on 05 December 2016, https://www.theguardian.com/uk-news/2016/nov/29/royal-navy-fleet-faces-depletion-review-finds

[99] House of Commons Defence Committee. Restoring the Fleet: Naval Procurement and the National Shipbuilding Strategy November 2016 p.22

[100] United Kingdom. Government, "National Security Strategy and Strategic Defence and Security Review 2015: First Annual Report 2016", Produced by Cabinet Office, last accessed on 15 April 2017, p.29

countering peer and near-peer threats in the anti-submarine environment."[101] The Type 31 will be a much more generic vessel, effectively creating a two tier frigate fleet. This will allow the U.K. to have a smaller fleet of highly capable ships along with smaller, cheaper more generic vessels.[102] In addition to attempting to increase the size of the RN it will also posture BAE, the prime contractor, to have a more marketable naval vessel for offer on the export market along with the more innovative and costly Type 26.

It is easy to draw parallels from the U.K. experience to Canada's NSS as Canada wishes to promote export through NSS activities. Unfortunately this creates Canada's own requirement to balance "ambitions". Geography alone creates the requirement for unique solutions as Canada is required to defend three oceans, operate in arctic conditions and often deploy lone assets to transit an entire ocean without support just to get to a theatre of operations. The CPF program designed and built a custom solution including efficient drive modes for transiting, adequate accommodations for the RCN's HR intensive damage control doctrine as well as including systems unique to cold weather operations such superstructure de-icing. These capabilities came at a high cost, $480 million for the first ship and $424 million for the last ship.[103] A Chief of Review Services report in 1999 identified the final version to be one of the most expensive for the time period as shown in Figure 4.

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[101] Type 26 Global Combat Ship (GCS) – Capabilities, Think Defence, last accessed on January 2017, http://www.thinkdefence.co.uk/the-type-26-frigate/type-26-global-combat-ship-gcs-capabilities/

[102] The three proposed Type 31 designs are all approximately 4,000 tonnes with smaller crews and much less capability than a conventional western frigate. More information can be found at: ThinkDefence, "Positioning Type 31 GPFF", last accessed on 27 March 2017, http://www.thinkdefence.co.uk/type-31-general-purpose-frigate-gpff/type-31-frigate-capabilities/

[103] Chief Review Services, "Report on Canadian Patrol Frigate Cost and Capability Comparison", National Defence, 26 March 1999,p.9

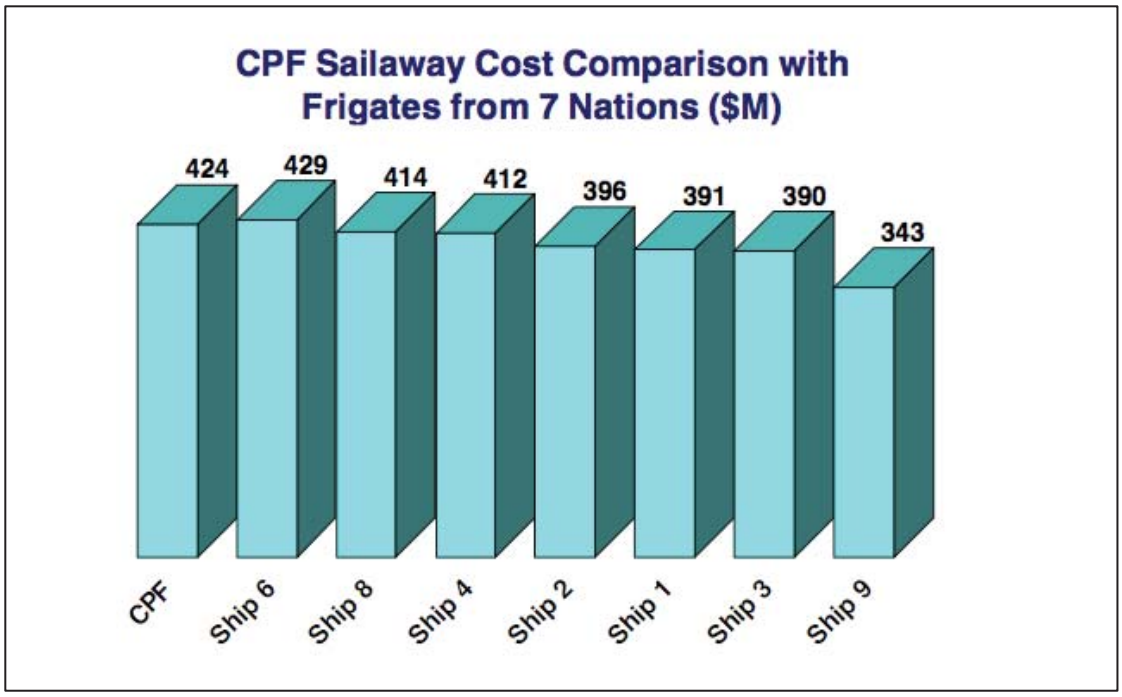

Figure 4: CPF Sail Away Cost Comparison
Source: Chief Review Services, "Report on Canadian Patrol Frigate Cost and Capability Comparison", National Defence, 26 March 1999,p.9

If Canada were to develop a vessel that meets the lengthy and intricate requirements that have been developed, it would surely be cost prohibitive from an export perspective much like the Canadian Patrol Frigate was cost prohibitive to export in the 1990's. Canada will need to make difficult choices between capability, specifically capabilities required by a North American warship, and Canada's export desires.

Canada has, however, had some recent naval export success in 2014 through Lockheed Martin Canada's (LMC) contract to be the Prime System's Integrator for refit of New Zealand's ANZAC Fleet where LMC provided a combat system's upgrade as part of the ANZAC mid-life refit program.[104] LMC is leveraging technology that was originally developed for the Halifax Class Modernization (HCM) Project and actively

[104] Lockheed Martin, "Exploring Canadian Naval Technology and Expertise", last accessed on 09 February 2017, (Lockheed Martin, 2017)http://www.lockheedmartin.ca/ca/what-we-do/aerospace-defence/naval-systems/new-zealand-anzac-frigate-systems-upgrade.html

pursuing export markets. A sound strategy as many nations would feasibly be interested in extending their platform's service life. The ability to conduct such sweeping changes during a mid-life refit has not been demonstrated often, Lockheed Martin Canada has done well to promote this niche product and the capability gains it provides compared to the alternative of acquiring a new fleet.

In the domain of maritime exports two countries dominate, the United States and France. The U.S. as an export leader is interesting but does not necessarily provide a model that any other country could emulate, France is quite different. France's defence procurement engine known as "la direction generale de l'armement" or DGA has three clear missions. First, to equip the defence forces, second to prepare for the future and finally to promote defence exports.[105] The DGA provides much of the direction to the French naval technology and shipbuilding company DCNS whose ownership is shared between the state (64%), Thales (35%) and employees (1%). Of the €16.9 billion in French defence exports in 2015, DCNS was responsible for approximately €16 billion.[106] This number will likely increase with the recent contract award announcement that DCNS will be delivering Australia's new submarine fleet, a contract valued at AUS$50 billion for twelve new submarines which will be designed and managed by DCNS and built in Adelaide's Osborne shipyards.[107] The success of DCNS is certainly worthy of further discussion as Canada would be extremely fortunate to experience a level of export

[105] France. Ministère De La Défense, "Présentation de la direction génerale de l'armement", last modified on 04 April 2017, http://www.defense.gouv.fr/dga/la-dga2/missions/presentation-de-la-direction-generale-de-l-armement

[106] French arms exports – the data behind the numbers, Military Balance (blog), 12 October 2016, http://www.iiss.org/en/militarybalanceblog/blogsections/2016-629e/october-96af/french-arms-exports-success-a148

[107] Anna Henderson, "Australian submarines to be built in Adelaide after French company DCNS wins $50b contract", *ABC News*, last modified 27 April 2017, http://www.abc.net.au/news/2016-04-26/pm-announces-france-has-won-submarine-contract/7357462

success approaching that of DCNS. The first point to note is the business construct, a majority state owned company, which is considered a competitive mega-player in the defence technologies industry. This clearly demonstrates the country's desire to build a company with strong export potential. DCNS then sought to collaborate on large design/builds such as the FREMM Class frigate where Italy was a partner.

The success largely stems from the business decision to develop a universal product focused on European nations as clients. The FREMM frigate delivered in this regard as it is large enough and capable enough to be considered a multi-mission platform, produced at a reasonable cost and it has served admirably for over ten years. As a result, the FREMM was exported to the Italian Navy, Royal Moroccan Navy and Egyptian Navy. This success has led to a new destroyer design currently known as the BEL@HORRA,[108] which will also be developed for export. The extraordinarily technical industry of submarine design and build have also been a strong business element for DCNS, able to export the *Barracuda* class submarine initially designed for the French Navy to Australia.

It is difficult to compare such a mature enterprise to Canada's current model, although some key differences can be drawn from France's approach to maritime exports:

a) France better understands the requirements of European countries and is therefore an attractive export source as proximal countries share many capability requirements as they share threats and operating environments;
b) France formed an independent company with government as major shareholder and Thales as major partner;

[108] DCNS has named its new frigate BELH@RRA® in reference to Europe's only giant wave: the Belharra. The first "a" transformed into an @ makes reference to the highly digital nature of the frigate proposed by DCNS.

c) DCNS developed the FREMM Frigate that is not overly complicated or unique to facilitate export.

The FREMM arguably establishes the benchmark in terms of the range of technology trade-offs that must be incorporated for a frigate to be attractive on the export market. The cornerstone of the business is the commitment to research and development. DCNS has invested €88 million in research and development in 2015 which represents close to three percent of its revenue, and is expecting to increase this to €120 million by 2017.[109]

It becomes clear that developing an export market in the naval domain is a concerted effort in itself. While stated as part of the DPS, expectations for export business as a result of the NSS should be balanced against the current reality of export potential of a warship dropping as capability increases.

Research and Development

Remaining relevant in the warship building industry requires research and development. The United States clearly demonstrates this with a research and development budget of US$17.35 billion for the Navy alone.[110] A staggering sum when compared to Canada's entire defence budget for 2016-2017 of CAN$19.7 billion[111] or approximately US$14.8 billion.[112] It is no wonder that the majority of world leading technologies, especially in the highly complex and rapidly moving domains of communications and combat systems reside in the US.

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[109] DCNS Group, "Key figures relating to innovation", last accessed on 06 May 2017, http://en.dcnsgroup.com/innovation/innovation-according-to-dcns/key-figures-relating-to-innovation/

[110] United States. Department of Defence, "Fiscal Year (FY) 2017 President's Budget Submission February 2016", last accessed on 10 April 2017 on, http://www.secnav.navy.mil/fmc/fmb/Documents/17pres/RDTEN_BA1-3_BOOK.pdf

[111] Canada. National Defence and Canadian Armed Forces, "Defence Highlight: Budget 2016", last accessed on 07 April 2017, http://www.forces.gc.ca/en/news/article.page?doc=defence-highlights-budget-2016/inbg2b1d (Canada. National Defence and the Canadian Armed Forces, 2016)

[112] Exchange rate as of 15 April 2017, 1 US Dollar equals 1.33 Canadian Dollars.

Other countries have realized successes with budgets that non-superpowers could sustain. For example the U.K.'s research and development budget (not including nuclear) of 400 million pounds[113] (CAN$660.3 million)[114] has facilitated a national industry with many leading edge naval technologies. Australia and the Netherlands have also made innovation a priority, investing sizable sums with the hopes of igniting research and development hubs.

Australia has committed to AUS$1.6 billion dollars in funding over the next decade which include the following:

a) Establishment of the Centre for Defence Industry Capability;

b) A Next Generation Technologies Fund to invest in strategic technologies; and,

c) New Defence Innovation Hub to undertake collaborative innovation activities.[115]

This has invited much interest in Australia with a consortium of fifteen universities, the Defence Science Institute, Australian Industry Group and the Australian Industry & Defence Network putting forth a proposal for an *Australian Maritime Innovation Centre.* The consortium has suggested an ambitious beginning to work in the domains of stealth, weaponry, propulsion, oceanography, material, communications and, command and control.

The Netherlands has also set out a clear goal of "strategic knowledge positioning" that will provide the guidance to knowledge institutions and industry on the government's priorities which they have clearly outlined to be:

a) Integrated (sub-) system design and development;

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[113] "Accessing UK Research and Development" last accessed 03 March 2017, https://www.albertacanada.com/AIS-AERO_Accessing_UK_Defence_Research_and_Development.pdf

[114] exchange rate on 02 Jan 2017, 1 British pound equals 1.65 Canadian.

[115] Australian Government. Department of Defence, "2016 Defence Industry Policy Statement", (Commonwealth of Austrailia, 2016) p.11

b) Sensors, C4I and automation;

c) Advanced materials and components;

d) Simulation and simulators for educations and training; and,

e) Electronic and information protection / weaponry.[116]

If Canada is to truly become a contender in the shipbuilding domain, with the hopes of export potential, innovative solutions will be required; for the most part these solutions will likely come from research and development. While Canada has comparably invested in R&D with an annual budget of CAN$350 million with 1400 employees, it is not as ideally set up to support a defence industrial policy as it appears to be missing the close networks with industry that are prevalent in most other cases above. Listed as a key aspect of the NSS when first envisioned, it has been given only moderate support to date. This position was supported by several evaluations of Canada's Defence Science and Technology Program.[117]

Comparing the Canadian defence research model to others it becomes clear that other nations place much more importance on industry collaboration and developing niche skills. A 2015 evaluation of the Defence Science and Technology Program found that due to the lack of an external engagement strategy and lack of sufficient procurement

[116] Netherlands Government. "The Netherlands' Defence Industry Strategy", 10 December 2013, https://www.government.nl/binaries/government/documents/publications/2014/10/22/the-netherlands-defence-industry-strategy/the-netherlands-english-dis-december-2013-2.pdf+&cd=1&hl=en&ct=clnk&gl=ca

[117] Canada. Chief Review Services , "Evaluation of Science and Technology Program", April 2015, last accessed on 14 April 2017, http://www.crs-csex.forces.gc.ca/reports-rapports/2015/244p1258-212-eng.aspx, Key Finding 11. Also this article written by the President of the Canadian Association of Defence and Security Industries (CADSI) Christyn Cianfarani, Defence R&D critical to Canada's innovation solution, *Globe and Mail*, Last modified 28 September 2016, http://www.theglobeandmail.com/report-on-business/rob-commentary/defence-rd-key-to-canadas-innovation-solution/article32085597/

mechanisms that they were largely impeded from developing external partnerships.[118] Another finding generated by key industry representatives was that Defence science and technology needed to identify its priority and niche capabilities.[119]

Naval research and development certainly has many non-transferable specialties but it also shares many others with civilian shipbuilding trades. R&D investments can therefore support the greater maritime industry not simply those involved in naval business. As an example, both the civilian and military sectors are striving for greater energy efficiency, the civilian sector to increase profits and the military sector to demonstrate environmental stewardship and ensure that the power demands of future high-energy weapons and sensors can be met.

The link between a strong defence industry and research and development is unmistakable. Countries that focus on generating export markets and those who place high value on knowledge also invest a great deal in research and development. In the Navy it also carries additional benefits in such areas as industry longevity and integration.

As naval platforms serve for thirty years, research and development is key in many ways. Firstly, a company which has had some success in the research and development domain is more likely to still be solvent; if they are still in business they are more likely to keep spare parts in stock and maintain intimate knowledge of the products that they have sold in the past. The second involves integration which is quickly growing to be one of the largest obstacles in vessel refits. New technology is constantly being introduced into platforms that are becoming increasingly integrated. A company with a

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[118] Canada. Chief Review Services , "Evaluation of Science and Technology Program", April 2015, last accessed on 14 April 2017, http://www.crs-csex.forces.gc.ca/reports-rapports/2015/244p1258-212-eng.aspx, p.24

[119] *Ibid*.

robust research and development program is more likely keep pace with future demands and be better positioned to advise and/or provide service.

Canada's renewed support for Canadian industry and technology will be a challenge to sustain without greater support to the underlying research and development, especially in the maritime domain where other nations are investing heavily to get ahead. The NSS has yet to demonstrate that it has had the R&D impact required to spur the multi-decade innovation programs required for Canada to reduce our reliance on other nations.

Obsolescence

The analysis completed above through the recent study of peer nation's warship building highlights that the probability of fifteen Canadian Surface Combatant platforms being delivered is low. The more compact the fleet, the greater the technical risk of obsolesce during through life becomes. Many components are bespoke for warships and rely upon industry to carry serviceable spare parts for decades. The combination of a thirty-five year warship service life and low production numbers creates the environment for rampant obsolescence. This risk of obsolescence can then be exacerbated further with defence industrial policies. For example, the requirement for a proportion of the contract value to be awarded to small and medium enterprises (SME) forces larger prime contractors to often venture away from known and trusted suppliers in order to meet government thresholds. While the intent is clearly to support the growth of small companies, it can also serve to artificially support a company. When the initial procurement contract has come to an end, many small companies have issues remaining

viable. The *Halifax* Class, with twelve platforms commissioned has already had to deal with severe obsolescence issues in the platform's twenty plus years of service.

An analysis of the obsolescence database maintained by the *Halifax* Class Program Management Office[120] clearly indicates that an acute problem already exists with regards to obsolescence, in most cases these components were initially procured in Canada. If this has developed into a problem for a twelve vessel fleet, the threat of obsolesce issues regarding the *Harry DeWolf* and *Queenston* class will need to be closely monitored, an additional technical risk that the Director General Maritime Equipment Program Management (DGMEPM) and RCN will inherit from DPS.

Integration and Complexity

The complexity involved in today's state of the art warships is quite spectacular. What was seen a short time ago as a complex system of systems is quickly becoming one singular super-system. In considering the risk involved with developing such a complex weapon, one must be reminded that ships are unique in that they are built without the luxury of a prototype. It was therefore decided that a short analysis of recent design and build failures is valid to establish that even for experienced naval shipyards, shipbuilding is not always a success.

The U.K.'s *Daring* class destroyer pioneered the Integrated Electric Propulsion (IEP) concept where the propulsion and electrical power generation systems were both dependent on the same main engines, in this case Rolls Royce WR-21 gas turbines. These engines were also leading edge, instituting fuel efficiency technology that was revolutionary for the time. Shortly after delivery of first ship mechanical breakdowns

[120] Information was provided by Mrs. Deborah Riley, the Class Program Management Coordinator at DGMEPM.

started to persist. The new engines would inexplicably shut down without warning removing propulsion as well as electrical power generation resulting in a completely dead ship. This flaw which was identified in 2009 will take until 2020 to be repaired across the fleet. Named Project Napier, repairs will require extended repair periods where ships will need to be drydocked and holes cut in the side, significant modifications will then need to be made to fit upgraded diesel engines onboard so the ships will not have to rely on the WR-21.[121] Due to the engines meeting all build specifications supplied by the MoD, the taxpayer will be responsible for the £250 million cost of the repair.[122] Further mechanical failures plague the class as they are unable to sustain operations in extremely hot environments. The repair for this issue will cost £1 billion, a cost to be paid once again by the U.K. taxpayer.[123] The U.K. are not alone with experiencing difficulty with warship design, the United States' two most recent classes have been victim to significant mechanical issues.

The United States Littoral Combat Ship (LCS) is a cutting edge platform capable of reported speeds of 44 knots (over 80 km/h).[124] In addition, it was also an experiment with a new interchangeable mission module concept. The LCS has unfortunately been hampered by engineering failures since inception, costing millions of dollars in repairs. One of the direct causes of these failures was "unreliable assessments of technical and integration risk" according to John McCain who was the Senate Armed Services

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[121] George Allison, "Cost of Type 45 Destroyer fix revealed", *UK Defence Journal*, last accessed on 22 March 2017 at https://ukdefencejournal.org.uk/cost-type-45-destroyer-fix-revealed/

[122] *Ibid*.

[123] Tom Batchelor, "Taxpayers foot 1 Billion bill after MoD 'failed to properly test' Type 45 destroyer engine", *The Express*, 22 July 2016, last accessed on 22 March 2017 at, http://www.express.co.uk/news/uk/692341/Type-45-destroyer-engine-problems-analyst-claims-MoD-failed-properly-test-engines

[124] IHS Jane's Fighting Ships 2016-2016, IHS Global Limited, Surrey, p.946

Chairman at the time.[125] Some of these failures were so severe that Micheal Gilmore, the Pentagon's Director of Operational Test and Evaluation, stated that the fleet "have a near-zero chance of completing a 30-day mission, the Navy's requirement, without a critical failure of one or more seaframe subsystems essential for wartime operations."[126] These failures ultimately led to the decision to cease production of the class and the relegation of existing vessels to training roles.[127] Unfortunately this was not the only ongoing issue with the U.S. Fleet at the time.

The *Zumwalt* class has pushed maritime technology and innovation in almost all regards, with a cost of US$4.4 billion per unit for construction costs alone to prove it. The *Zumwalt* class was also plagued with mechanical failures to accompany the cost overruns that were over 40 percent.[128] Ultimately only three were produced and once again the program was no longer funded due to engineering issues and cost overruns. The U.S. chose instead to fund addition builds of the *Arleigh Burke* class. While the program has been continuously upgraded, now on Flight III, the Arleigh Burke program is certainly a de-risked program, able to produce two ships a year at a total of approximately US$1.4 billion each.[129]

By contrast the FREMM class frigate has been operated by France, Italy, Egypt and Morocco since 2007 without a major engineering failure. This class, build with

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[125]Jamie McIntyre, "Penagon's top tester: Littoral ships 'have a near-zero chance of completing a 30 day mission'", *Washington Examiner*, 01 December 2016, last accessed on 25 March 2017 at , http://www.washingtonexaminer.com/gao-the-miracle-of-the-lcs-didnt-happen/article/2608619

[126] *Ibid.*

[127] Giovanni de Briganti, "US Navy Drops LCS Plans, Concept After Latest Failures", *Defence-Aerospace.com*, last accessed on 22 March 2017 at, http://www.defense-aerospace.com/articles-view/release/3/176873/us-navy-drops-lcs-plans,-concept-after-latest-failures.html

[128] Ronald O'Rourke, "Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress", Congressional Research Service, p.5

[129] *Ibid*.

advanced but not high risk technologies have proven successful in conducting deployments around the globe.

These examples serve to demonstrate the complexity in designing and constructing a warship during such a technologically advanced period. While the AOPS and JSS will not require this level of complexity or integration, the CSC program will depend upon it as it will certainly operate in high threat environments. How this risk is mitigated or compounded by industrial policy remains to be seen. For example, prime integrators may be required to deviate from mature designs with known subcontractors to accommodate Canadian content that may produce positive innovative solutions or conversely introduce major integration issues. Either way, given the repair costs and repairs times indicated above, Canada should be very cautious in regards to how DPS and NSS will influence technology insertion given that the CSC will quickly become the sole frigate/destroyer in the fleet.

CHAPTER 7: A MORE BALANCED APPROACH

The analysis above has highlighted several instances where the defence industrial policy could have negative impacts on capability. This supports the idea that, as far as the RCN is concerned, the current defence industrial framework may be sub-optimal. The findings above suggest that a defence industrial policy that is not only tailored for the unique aspects of naval acquisition but also the long-term sustainment environment may also provide greater market stability. The most substantial means of reducing the technical risk involved in acquiring warships is to increase the number of platforms. In short, a transition from a continuous build strategy to a more long-term continuous sustain approach may provide greater industrial benefits and reduce technical risk while also delivering greater capability to the RCN.

Continuous Build no Longer Viable

The NSS was built on the cornerstone of establishing continuous shipbuilding in Canada. Given the fact that resource constraints have already reduced the AOPS and JSS build programs and the CSC program is at high risk of not being able to deliver fifteen ships, the questions arises of 'how continuous is continuous? Seaspan Inc. on the west coast is currently scheduled to deliver one polar icebreaker to the Canadian Coast Guard in 2021, after which time no other shipbuilding projects are projected. The east coast Irving Shipyards Inc., is faced with a more acute problem in that the AOPS program has reduced platform numbers along with fifteen CSC's seen as unlikely. This is inducing additional risk as the AOPS program could be complete without the CSC platforms ready for construction. A labour gap such as

this is exactly what the NSS set out to avoid in the "continuous build" strategy. It can be surmised that this risk was factored into the change in procurement strategy from a design build program to a mature design program.[130] Even with this change Kevin McCoy, Irving's President, has stated that "There is going to be some kind of gap".[131] Even if a continuous build between AOPS and CSC is somehow achieved, a reduced CSC fleet will end the continuous shipbuilding program well before the anticipated 2041 construction end date. At this point the Coast Guard and RCN will have a new fleet of ships with service lives of over thirty years. This highlights the major risk in the NSS in that it assumed the planned number of platforms would be constructed. Consider that if ten CSC platforms are built, the NSS will only deliver 60% of the naval vessels initially planned.[132]

The only remaining fleet under question is the submarine fleet. At this point it is too early to predict what will happen largely due the fact that the submarine program was not included in the National Shipbuilding Strategy. In reality the continuous shipbuilding program which "cut steel" in 2014 could be complete on the west coast by 2025 and on the east coast ten years later. At which point, without

[130] The presumption is based upon the schedule risks with developing a unique design and the follow on impact that delays would have on the construction program.

[131] Lee Berthiaume, "Gap in federal shipbuilding work could lead to Halifax shipyards layoffs", *The Canadian Press*, 3 February 2017, last accessed on 23 March 2017 at, http://www.cbc.ca/news/canada/nova-scotia/irving-shipbuilding-work-gap-ship-contracts-layoffs-1.3965113

[132] This is based upon the premise that acquiring 15 ships is an unlikely option given recent cost estimates of between $40 -$50 billion and the current fiscal environment. For more information see – Marieke Walsh, New plan for warships will likely hit $40 billion price tag: defence analyst", Global News, 13 June 2016, Last accessed on 23 April 2017, http://globalnews.ca/news/2758781/new-plan-for-warships-will-likely-hit-40-billion-price-tag-cefence-analyst/

export business, the shipbuilding industry will likely atrophy to the approximate condition it was before the NSS began.[133]

These conditions provoke an evaluation of the current NSS with the vision of finding solutions that are more feasible for both industry and the RCN. From the analysis above it is clear that a shift is required from a shipbuilding focus to a ship repair and refit focus.

Continuous Sustain Focus

Little escapes the public eye in terms of defence acquisition projects, especially when billions of dollars are being discussed. In contrast, surprisingly little is mentioned with regards to the strategy to sustain these vessels over the long term. Counting from the delivery of the first AOPS in 2018 to forty years after the delivery of the last CSC will surely eclipse the half-century mark in terms of maintenance requirements. And while perhaps counter intuitive due to the efficiencies in maintenance delivery, maintenance costs are increasing and will likely continue to do so in the future. NSS estimates that $500 million to $600 million will be spent annually on maintenance not including the *Halifax, Victoria* class or existing Coast Guard vessels.[134] Two main concepts are driving this increase, the increase in complexity of naval platforms and the increasing aversion to assuming technical risk.[135]

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[133] This is based upon the 12 *Halifax* class being replaced by approximately 12 CSC vessels and the 4 *Iroquois* class destroyers and 2 *Protecteur* class replenishment ships being replaced by 4-6 AOPS and 2 JSS.

[134] Martin Auger, "The National Shipbuilding Procurement Strategy: A Five Year Assessment", (Ottawa: Parliament of Canada, 2015) p.11

[135] While difficult to demonstrate how much this cultural change has impacted maintenance a few qualitative indicators do exist. Firstly, Canada has recently awarded a contract to Lloyd's Register estimated to be $90 million to develop classification and certification services of combatant ships as part of

As previously stated the maintenance costs for the *Harry DeWolf* class patrol ship and *Queenston* class replenishment will be almost equivalent to the build cost. The cost to maintain a modern warship can be even more staggering. The Federal Government released a 'cradle to grave' value of $105 billion dollars to acquire, operate and maintain 15 CSC ships for 30 years[136]; subtracting the $26.2 billion construction costs apportions an operating and maintenance demand of $78.8 billion. The study was likely limited to a thirty-year service life to reduce the total projected costs as maintenance increases disproportionately approaching end of product life, as demonstrated in Figure 5.

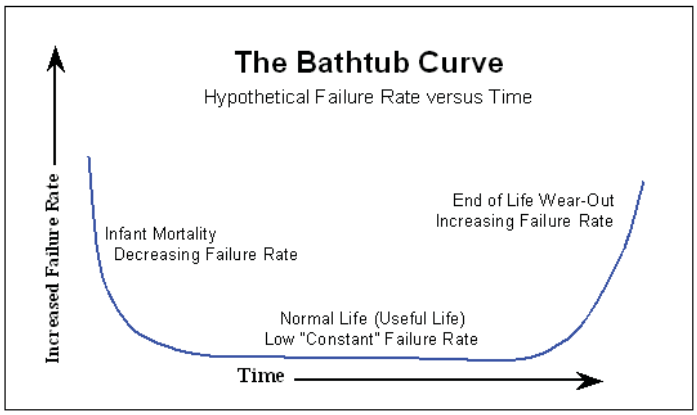

Figure 5: Product Failure Model
Source: Dennis Wilkins, The Bathtub Curve and Product Failure Behaviour Part Two: Normal Life and Wear-out", *Reliability HotWire,* Issue 22 (December 2002), http://www.weibull.com/hotwire/issue22/hottopics22.htm

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the Materiel Regulation Framework. More information can be found https://buyandsell.gc.ca/procurement-data/tender-notice/PW-ML-040-24946

[136] Eric Morse, "Why $100-billion to maintain military ships is a a meaningless number", *The Globe and Mail*, 14 November 2013, last accessed on 11 April 2017, http://www.theglobeandmail.com/opinion/why-100-billion-to-maintain-military-ships-is-a-meaningless-number/article15436305/

This study, supported by a PSPC estimate of the total through life cost of CSC being $99.2 billion[137], highlights the potential for significant industry business over the long term. The impact of each reduction from the initial plan of fifteen ships limits the maintenance support required in the future.

Supporting this argument from an economic perspective, in-Service support not only makes the largest direct and indirect contribution to GDP[138] but it is also the largest direct and indirect GDP impact multiplier as show in the Figure 6 below.

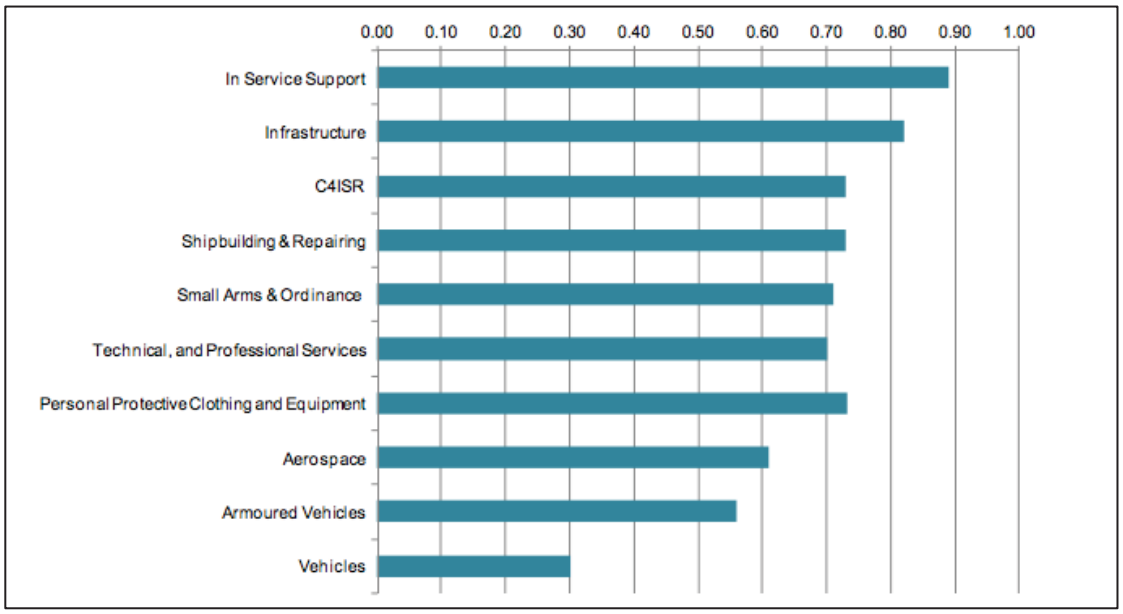

Figure 6: Direct and Indirect GDP Multiplier by Sub-Sector
Source: KPMG, "Economic Impact of the Defence and Security Industry in Canada", Report released by the Canadian Association of Defence and Security Industries (CADSI), p.9

From this it can be deduced that focussing on a robust in-service support industry would provide Canada with an attractive strategy for long-term economic benefits. Unfortunately, the industrial policy focus on shipbuilding will potentially sacrifice in

[137] Martin Auger, "The National Shipbuilding Procurement Strategy: A Five Year Assessment", (Ottawa: Parliament of Canada, 2015) p.10

[138] KPMG, "Economic Impact of the Defence and Security Industry in Canada", Report released by the Canadian Association of Defence and Security Industries (CADSI), p.9

service support revenue generation, as only a fraction of the initially proposed fleet will likely be constructed.

A continuous sustain focus is also advantageous from an operator/maintainer point of view. A robust Canadian maintenance industry is essential to national security, perhaps more so than shipbuilding as it is in-service support that directly impacts a ship's readiness to deploy and ability to affect repairs and complete its mission once deployed. This repair ability, including specialized engineering support, supply chain management and the ability for industry to surge in time of need is far more tangible to protecting Canada than the ability to produce a warship given a fifteen-year timeframe.

What Would a More Balanced Approach Look Like?

As Canada has embarked on this journey several years ago perhaps it is appropriate to consider alternate Courses Of Action (COA) that meet the intent of the defence industrial policy as well as provide the RCN with the potential to approach the initially desired fleet size.

Any alterations must consider the realities of current commitments and the parameters that have been set. The AOPS and JSS contracts have been awarded so changes to these would be minimal at best. The AOPS build is underway with the hopes of acquiring six vessels, and the JSS will be underway shortly with a build plan of two. CSC remains constrained within the NSS but as it is a strategy and not a contract, options for the future do remain somewhat flexible.

The remainder of this section will define the Courses of Action (COA) that provide greater sustainability to the defence industry in the long-term while delivering the greatest capability to the RCN.

The procurement strategy for CSC has certainly been an iterative process. The government has already demonstrated that it is willing to relinquish its initial plan to design and build warships in Canada with the intent to purchase a mature design in the hopes of reducing risks to cost, schedule.[139] This follows suit to the recent AOPS and JSS programs that were both based upon existing designs. The vision of developing a fleet that would meet the needs of Canadians while also providing a long term base for the naval maritime industry points towards a clear end state; more platforms equals more navy and therefore more industry supported sustainment.

At the moment a platform cost of $3 billion is likely, by the time the first hull is constructed in the early 2020's a cost of $3.5 billion would not be unrealistic.[140] Leveraging other solutions could provide Canada with a more palatable cost per unit. The examination below demonstrates two avenues which have enjoyed recent success, the collaborative approach and the multi-shipyard approach.

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[139] The government's procurement strategy evolved from a design-build strategy to purchasing a mature design. This criteria was then amended to allow BAE to participate with the yet to be build Type 26 which they have been contracted by the Royal Navy to build with a planned start date of 2017. For more information see – David Pugliese, "Canada Widens the Aperture in Search of New Warships", *DefenceNews*, 2 November 2016, last accessed on 22 April 2016, http://www.defensenews.com/articles/canada-widens-the-aperture-in-search-of-new-warships

[140] This is based upon a very conservative 3 percent cost increase per year over 5 years. A higher number such as 7 percent would yield a cost of $4.2 billion.

Collaborative Approach

The collaborative approach such as joining the U.K. with the Type 26 Global Combat Ship or the French with the *Belh@rra* class would likely allow for costs to be greatly reduced through economies of scale. These economies of scale would generate greater odds that the RCN could acquire close to the ultimate goal of fifteen vessels as initially planned. Maintaining such a large fleet would then principally be the task of the Canadian shipyards which would serve to establish long-term stability within industry. The increased industrial base inventory through a collaborative approach also greatly facilitates sustainment both in terms of security of the supply chain global and repair capacity. Canada's current submarine program certainly serves as a clear example of such an issue as acquiring spare parts, and expertise has become an extremely difficult and expensive endeavour.[141]

This option would require the vessels, or a portion of the vessels, to be constructed outside of Canada, effectively trading short-term gain for long term industry stability. The largest challenge of this option would be the political risk that must be taken to explain the purpose behind an offshore build.

Multi-Shipyard Approach

The multi-shipyard approach has been a successful strategy for countries such as Norway and the Netherlands. The recent knowledge in modern warship building developed by such countries such as Italy, France, Spain and Australia

[141] For several decades Canada was able to maintain the fleet of *Oberon* Class submarines without much issue. This was largely due to the fact that while Canada owned three submarines, a total of twenty-seven submarines were in service around the world providing an adequate industrial base for companies to export spare parts. Alternately, Canada now owns the only four *Victoria* Class submarines that were ever made which had resulting in Canada spending hundreds of millions on hard to find spare parts. More info can be found at: Andrea Gunn, "Spare parts harder to find for Victoria –class submarines, *Herald News*, Last modified 30 August 2016, http://thechronicleherald.ca/novascotia/1297488-spare-parts-harder-to-find-for-victoria-class-submarines

could be leveraged to find significant cost reduction strategies. A multi-shipyard approach would involve a shipyard with recent naval shipbuilding experience constructing the first few vessels while the Canadian shipyard is able to learn from the initial build. Then depending on price and capacity the remaining ships could be divided between the two shipyards. This hybrid solution would reduce cost, decrease technical risks and compress the build schedule (which also serves to reduce cost given the inflation rate estimates). This strategy, similar to the one above, would result in a greater number of platforms which would generate the proposed continuous ship repair strategy. While promoting this concept may not satisfy the Canadian shipyards' appetite for labour over the short term it does once again establish a long-term maintenance requirement.

Given the current political environment and the history with the F-35 program, the collaborative approach would carry more political and cost risk than the multi-shipyard approach. For these reasons, the multi-shipyard approach was determined to be the preferred COA for the CSC. This would only impact the east coast shipyard as other RCN and Canadian Coast Guard build programs would be untouched.

Technical Advantages of Preferred COA

This approach preserves Canada's desire to re-establish shipbuilding in Canada as it only represents a small portion of the ships involved in NSS being built elsewhere. It also satisfies the intent of generating employment for several generations, perhaps more efficiently than the current shipbuilding program. This maintenance focussed approach would also require the transfer of Intellectual

Property and technical knowledge to support the fleet. This approach does not preclude Canadian components from being used but it would create an environment where companies would likely have a greater interest in updating components with more platforms to support translating to greater return on research and development investments. It also reduces economy of scale risk due to through the requirement for a larger supply chain to support the vessels.

This approach remains flexible in regards to how many platforms are built in Canada verses outsourced as well as the order they are constructed. While the oversight for the outsourced platforms would be reduced if the first few vessels were built in Canada, from a cost and technical risk perspective it would be more feasible to have the mature shipyard construct the first few platforms and Canada start construction once the design is validated. Such a proposal was recently submitted during the Request for Proposal for CSC.

The Italian shipbuilding company Fincantieri expressed concerns that the winning bidder would have a very limited role in the CSC program which would provide only "limited incentive"[142] for generating a bid which was noted as including "overwhelming requirements for technical data and other information."[143] In addition, concern was expressed over the requirement to provide valuable intellectual property of the designs, access to established supply chains and transfer of technology to Irving and Canada. In addition, concern was raised over the bid

[142] David Pugliese, "Canadian minister defends naval project after Fincantieri criticism", *Defence News*, 15 February 2017, last accessed on 26 March 2017, http://www.defensenews.com/articles/canadian-minister-defends-naval-project-after-fincantieri-criticism

[143] David Pugliese, "Bidding on Canadian Surface Combatant Program to be delayed, federal government confirms", *Ottawa Citizen*, 17 February 2017, last accessed on 25 March 2017 at http://ottawacitizen.com/news/national/defence-watch/bidding-on-canadian-surface-combatant-program-to-be-delayed-federal-government-confirms

request as it requires warship designers to "provide a warranty on the integration of technology into their designs, even though they are not responsible for buying that equipment."[144] As a result Fincantieri stated to Minister Foote that "If the current proposed procurement approach is retained, then it will be very difficult for Fincantieri to obtain approval to bid from its board."[145] Four of the twelve companies have since come forward requesting an extension to the RFP closing date that has since been amended from 27 April 2017 to 22 June 2017.[146]

Keys to Success

While this research paper would be considered incomplete without providing alternative solutions to current procurements, the true value of the research conducted was thought to be in establishing the keys to success that serve to reduce the technological risks as well as support the Canadian defence industry. This section will examine what are determined to be the key findings that would support the current procurement approach as well as either of the two proposed COAs.

Cluster Maritime Industry

The current National Shipbuilding Strategy endeavours to create an environment where Canada is capable of building and maintaining a naval warship enterprise. The reality is that Canada, along with most other western nations,

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[144] David Pugliese, "Canadian warship project a mess, as one of world's largest shipbuilders threatens minister it won't bid", *Ottawa Citizen*, 5 February 2017, last accessed on 23 March 2017 at http://news.nationalpost.com/news/canada/canadian-warship-project-a-mess-minister-told-as-one-of-worlds-largest-shipbuilders-threatens-not-to-bid

[145] *Ibid*.

[146] David Pugliese, "Bidding on Canadian Surface Combatant Program to be delayed, federal government confirms", *Ottawa Citizen*, 17 February 2017, last accessed on 25 March 2017 at http://ottawacitizen.com/news/national/defence-watch/bidding-on-canadian-surface-combatant-program-to-be-delayed-federal-government-confirms

depend largely upon the United States for state of the art technologies. It would therefore be unreasonable to assume that Canada could easily generate a robust industry with such an overpowering competitor as a neighbouring state. Focussing on specific aspects of naval engineering where Canada has an established market or has deemed the domain as being imperative to national security would be a more feasible solution.

Other countries have realized that focussing on a few inter-related businesses, commonly referred to as clusters should form the base of defence industrial policy. These clusters provide a host of economic benefits such as supporting businesses who have had success with exports while avoiding higher risk activities such as attempting to ignite business with few or no mutually supporting businesses in highly competitive markets. This methodology also has significant technical impacts to naval warships. This approach would allow Canada to acquire the best equipment at competitive pricing. Canada could award contracts and promote export in areas of success. These clusters seek synergies through greater internal development and often continue to expand the boundary of the clusters capability. As highlighted in the Literature Review, many countries have embraced this approach including the United States. A 2011 document released by the Center for Strategic and Budgetary Assessments recommended that " The United States' defence industrial base strategy should ensure that preservation of those few sectors that are currently critical to American national security", it then continues to recommend the practice of "ruthlessly underfunding or jettisoning any sectors that

cease to be critical."[147] Not only is this concept being used in other countries already, it is not a new concept to Canada. Reports such as the PSPC (then PWGSC) commissioned report by Mr. Tom Jenkins acting as a special advisor promotes the use of what is referred to as Key Industrial Capabilities (KICs), to focus the scope of defence industrial activities to strike a balance between "ambition and practical management realities"[148] This report is supported by a prior KPMG report commissioned to advise CADSI in 2012.[149] In fact, Brian Tobin as Minister of Industry initiated a cluster approach to "focus on opportunity, growth and innovation in niche markets where Canada can compete" in maritime industries as far back as 2001 with the titled "A New Policy Framework for the Canadian Shipbuilding and Industrial Marine Industry" document.[150]

Employing the cluster concept would therefore allow Canada to provide valuable support to industries that are competitive in the global marketplace which supports the intent of the defence industrial policy while also providing the RCN with state of the art equipment. At the moment shipbuilding is listed as a KIC although the term appears to be all encompassing as it not only includes shipbuilding but also the supply chain and naval in-service support.[151] This definition includes almost all aspects in the naval shipbuilding and repair segment. Other countries such as Norway, Australia and the Netherlands have been much more specific in the approach of identifying focus areas. A more directed list

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[147] Center for Strategic and Budgetary Assessments, "Sustaining Critical Sectors of the U.S. Defence Industrial Base", last accessed 10 April 2017, http://csbaonline.org/uploads/documents/2011.09.20-Defense-Industrial-Base.pdf, p.xiii

[148] Canada First: Leveraging Defence Procurement Through Key Industrial Capabilities, P.28

[149] KPMG, "Economic Impact of the Defence and Security Industry in Canada", Report released by the Canadian Association of Defence and Security Industries (CADSI)

[150] Government of Canada, "A New Policy Framework for the Canadian Shipbuilding and Industrial Marine Industry: Focusing on Opportunities 2001 ", Industry Canada, Ottawa: 2001

[151] *Ibid*,

of naval KICs would be more inline with the intent of identifying KICs. In this case it would be ship maintenance and repair. An additional requirement in developing the idea of clustering is an equally targeted research and development program.

Targeted Research and Development

Although Canada has recently recognized the importance of innovation[152], Canada's commitment to Research and Development remains significantly below the majority of our peer nations as shown in Figure 7 below.

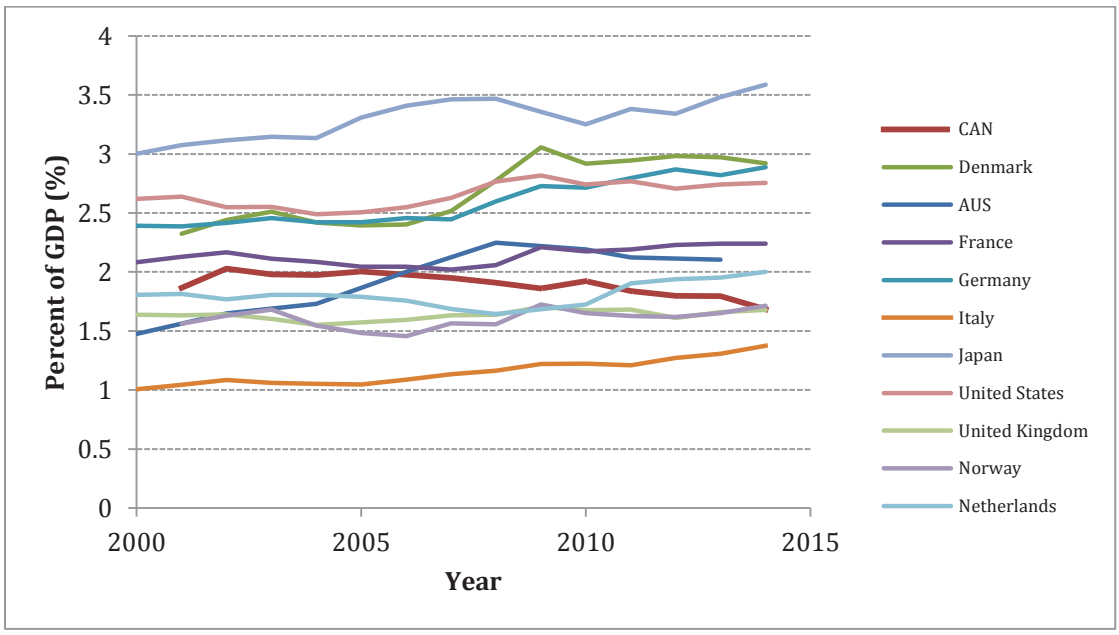

Figure 7: Research and Development by Nation
Source: Chart generated from data from OECD Data, "Gross Domestic Spending on R & D", https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm

The research described in previous chapters highlights that countries that have done well in the naval industry have heavily endorsed research and development, quite expected given the complexity of naval equipment. Furthermore, the countries

[152] Prime Minister Justin Trudeau, "Minister of Innovation, Science and Economic Development Mandate Letter", last accessed on 05 April 2017, http://pm.gc.ca/eng/minister-innovation-science-and-economic-development-mandate-letterquote minister mandate letter

that have adopted a cluster approach such as the Netherlands, France and Denmark all have robust research and development programs. At the macro-level, based upon Figure 7, it can be argued that Canada undervalues research and development; the naval engineering environment does not appear to be any different considering that other countries have established partnerships with universities and academic associations.[153]

These two aspects are key to safe-guarding Canada against technological risks while remaining under a framework that provides benefits to the economy. In addition, the link between R & D investments serving to propel clusters forward in globally competitive markets is clearly foreseeable.

From Concept to Practice

Adapting these concepts into practice will ultimately be mostly a business decision by industry. Canada, in this case the naval engineering environment, can however alter policies and organizations to facilitate and incentivize industrial clusters in naval engineering.

At the forefront would be greater efforts in establishing closer links between industry research and development programs and naval research and development. At the moment, as explained in the CRS evaluation of science and technology mentioned in Chapter 6, the DND science and technology program is not in much of a position to influence industrial R&D. The feedback from this study reached the conclusion that industry was not involved enough, primarily at early stages. These

[153] The RN has a dedicated partnership with University College London where dedicated programs exist to explore cutting edge technologies. Australia has also developed closer ties with the professional engineering association.

conclusions are similar to those studies that formed the genesis of the Defence Procurement Strategy in that government did not include industry early enough to help shape and ultimately deliver a feasible RFP.[154] The output of DPS to help solve this was the Defence Acquisition Guide; a document designed to "provide greater transparency on projected defence capability requirements".[155] The guide lists future acquisition programs along with a basic narrative and cost bracket.[156] The research and development domain may be able to leverage this concept and apply it to research and development. For example, DND could partner with Innovation, Science and Economic Development Canada and PSPC to release a similar research and development document. Such a document would highlight the national security priorities as well and those niche or cluster areas that government would consider partnering or investing with public industry.

In addition to amending or generating policy, organizations would need to coordinate in greater detail. Where Canada has developed a unique system of agencies to provide taxpayers with several checks and balances it also generates obstacles in coordination and prioritization. While the vision and intent of organizations such as DND, ADM(Mat), ADM(S&T), PSPC, and ISED are ideally mutually supporting, the reality is that friction points exist that can generate delays and alter requirements. Other nations such as France and most recently Australia

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[154] Tom Jenkins *et al*, Innovation Canada: A Call to Action, Public Works and Government Services, Canada, (Ottawa, 2011). This report shows that Canada is behind all other peer nations with regards to direct R&D investment and clearly favours indirect investment through tax incentives (page 6-2). The report indicates that businesses require *Risk Capital* (page E-3) in order to promote growth through innovation.

[155] Canada. National Defence and the Canadian Armed Forces, "Defence Acquisition Guide 2016", last accessed on 29 March 2017, http://www.forces.gc.ca/en/business-defence-acquisition-guide-2016/index.page

[156] *Ibid.*,

have combined many of these procurement agencies under one headquarters allowing for all organizations to operate under a common list of priorities allowing resources to be optimally allocated. Australia for example combined the Australia equivalent of ADM(Mat), PSPC and ISEDC into one unit called the Capability Acquisition and Sustainment Group (CASG) in order to "manage legal and commercial risk in the capability and procurement lifecycle."[157]

Ultimately both aspects discussed above describe an improvement in the unity of effort with regards to procurement and R&D. In addition to developing closer ties with industry it may also serve to expedite procurement.

[157] Australia. Department of Defence, "Contracting in CASG", last accessed on 30 March 2017, http://www.defence.gov.au/dmo/DoingBusiness/ProcurementDefence/ContractinginCASG/

CHAPTER 8: FUTURE WORK

During the research process, several aspects were identified as meaningful but for various reasons such as time or resources could not be incorporated into this report. This chapter has been included as an aid to any subsequent activities in this realm. Two areas have been identified of value, each are discussed in what follows.

The first area that could not be fully investigated due to time was obsolescence and the how future industrial capabilities might be impacted through a policy such as the ITB policy; more specifically the impact that obsolescence has had on the *Halifax* class. While the *Halifax* class Program Management Office has gathered data surrounding impeding issues with obsolesce the aggregate costs associated with program management, sustaining obsolete components or acquiring new systems to replace obsolete parts was not gathered in sufficient detail. As most of the obsolete parts came from Canada, this type of information would have provided additional evidence to the technical challenges posed by industrial policies.

The second task that would have contributed much to the equation was in-service support costing models.[158] While the costs were estimated for fifteen CSC platforms it would have been valuable to see the difference of in-service support costs between fleet sizes such as ten, fifteen and perhaps twenty CSC vessels. While examples from the *Victoria* and *Iroquois* class were used as evidence, disaggregated

[158] Canada relies heavily on third party cost analysis due to expertise as well to ensure results are seen as unbiased. ADM(Fin CS) is still developing draft costing models for operations and maintenance after being directed to develop more accurate cost models through the F-35 audit process.

through life cost estimates for CSC would have contributed greatly but were unfortunately not available for this report.

CHAPTER 9: CONCLUSION

Acquiring the fleet of tomorrow has become largely an economic evolution for political strategists, and will likely remain so without a precarious threat to the security of Canada's coastline. As such the NSS has invested heavily in supporting the Canadian economy through commitments to build Canadian Coast Guard and Royal Canadian Navy ships in Canada. In doing so Canada has accepted an increased level of technical risk, both during the initial build and the forty-year sustainment period that follows.

This paper has demonstrated that the technical risks associated with the RCN accepting the current Defence Procurement Strategy and National Shipbuilding Strategy are significant, both in terms of cost as well the ability to complete assigned missions.

This was first demonstrated through a brief literature review of countries that that have recently been, or are currently, involved in major naval fleet renewal programs. This chapter highlighted the various avenues for acquiring naval platforms from pure national security reasons to these heavily driven by economic offsets. The chapters that immediately followed discussed Canada's current industrial policy and more specifically the National Shipbuilding Strategy. Knowledge in these sections is required to establish how the framework is very

much a “one size fits all” approach which is not ideally suited for naval procurements.

Analysis was then conducted in key areas where the technical benefits required for national security diverged from economic benefits. This section emphasized that the ITB policy and NSS generated technical risks through impacting economy of scale, research and development, obsolescence, complexity and integration. Research has shown that these risks have been unfortunately realized already by several nations leading to drastic decisions being taken such as fleet reductions, extremely expensive repairs, and in the case of the U.S. taking vessels out of service.

This all served to confirm that the current continuous build strategy is no longer the optimum path for Canada. The continuous build strategy should be replaced with a continuous sustainment strategy where industry would be involved in the forty-plus year service life of each vessel. In addition to providing potential courses of action to complete the intent of the current shipbuilding program, long-term strategies were developed. These long-term strategies were built from the successes of our allies as well as key documents that were generated from within Canada. The two main keys to success were determined to be adopting a niche or cluster approach within naval industrial policy as well as increasing research and development spending but in a targeted way to support the clusters.

Canada is unlikely to waiver on the requirement to build naval ships in Canada, it should however be prepared for the potential consequences of using complex platforms as a means of cementing a naval shipbuilding capability in

Canada. As the CSC will, in due time, be the only warship in the Canadian Fleet, failing to deliver a capable ship that can be maintained for over forty years could ultimately sink the Royal Canadian Navy.

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