

Canadian
Forces
College

Collège
des
Forces
Canadiennes



Lieutenant-Commander James R.P. Brun

A MODERN CANADIAN SUBMARINE FORCE

JCSP 47

Master of Defence Studies

Disclaimer

Opinions expressed remain those of the author and do not represent Department of National Defence or Canadian Forces policy. This paper may not be used without written permission.

© Her Majesty the Queen in Right of Canada, as represented by the Minister of National Defence, 2021.

PCEMI 47

Maîtrise en études de la défense

Avertissement

Les opinions exprimées n'engagent que leurs auteurs et ne reflètent aucunement des politiques du Ministère de la Défense nationale ou des Forces canadiennes. Ce papier ne peut être reproduit sans autorisation écrite.

© Sa Majesté la Reine du Chef du Canada, représentée par le ministre de la Défense nationale, 2021.

CANADIAN FORCES COLLEGE – COLLÈGE DES FORCES CANADIENNES

JCSP 47 – PCEMI 47

2020 - 2021

MASTER OF DEFENCE STUDIES – MAÎTRISE EN ÉTUDES DE LA DÉFENSE

A MODERN CANADIAN SUBMARINE FORCE

By Lieutenant-Commander James R.P. Brun

“This paper was written by a candidate attending the Canadian Forces College in fulfilment of one of the requirements of the Course of Studies. The paper is a scholastic document, and thus contains facts and opinions which the author alone considered appropriate and correct for the subject. It does not necessarily reflect the policy or the opinion of any agency, including the Government of Canada and the Canadian Department of National Defence. This paper may not be released, quoted or copied, except with the express permission of the Canadian Department of National Defence.”

« La présente étude a été rédigée par un stagiaire du Collège des Forces canadiennes pour satisfaire à l'une des exigences du cours. L'étude est un document qui se rapporte au cours et contient donc des faits et des opinions que seul l'auteur considère appropriés et convenables au sujet. Elle ne reflète pas nécessairement la politique ou l'opinion d'un organisme quelconque, y compris le gouvernement du Canada et le ministère de la Défense nationale du Canada. Il est défendu de diffuser, de citer ou de reproduire cette étude sans la permission expresse du ministère de la Défense nationale. »

TABLE OF CONTENTS

Abstract	ii
Introduction	1
Chapter 1: Why Canada Needs Submarines	16
Chapter 2: Capabilities for a Canadian Submarine Replacement	25
Chapter 3: Canadian Submarine Procurement Options	47
Conclusion	62

ABSTRACT

Canada is a maritime nation, with strategic interests around the world. Today, challenges are emerging to the rules-based international order that has provided Canada with security and prosperity since the end of the Second World War. Amidst the shifting global strategic landscape, nations are recapitalizing and modernizing their submarine fleets. To remain competitive, Canada needs a modern, capable, and lethal submarine force. Canada's current submarines, the *Victoria* class, are maturing gracefully. Canada must initiate a process to determine the capabilities required for its next submarine. The global threat environment will place demands on Canada's future submarine fleet that exceed the capabilities of the *Victoria* class. The capabilities of this future fleet must be carefully considered, including which propulsion system meets Canada's strategic requirements. Finally, the method of procurement must be determined based on which process will provide Canada with the submarines it needs, while considering the cost of the project, and its impact on Canadian national security.

A MODERN CANADIAN SUBMARINE FORCE

INTRODUCTION

A modern and lethal submarine force is among Canada's best defences in an increasingly competitive and dangerous global environment. The Royal Canadian Navy (RCN) has intermittently operated submarines for over a century. Submarines are a critical element of the RCN's force structure, vital to defending the world's longest coastline, supporting alliance commitments, and projecting power across the world's oceans. Submarines are an economical and highly effective platform for a navy like the RCN. Canada's navy puts emphasis on surface ships with long endurance and submarines for coastal and continental surveillance and defence. An RCN without submarines would hardly rank as a credible navy, to be taken seriously by its closest allies. In effect, without submarines, the RCN would become a limited maritime force. Canada needs a modern submarine force capable of defending its maritime approaches along three coasts, and contributing to partner and alliance operations in support of Government of Canada strategic objectives.

Canada's current submarines, the *Victoria* class, have undergone extensive refits after delivery to Canada but are over thirty years old. To keep the submarines operating until the mid-2030s, the class is undergoing a modernization project that upgrades "platform and combat systems with targeted enhancements in order to maximize availability, improve operational effectiveness, manage obsolescence, and above all improve habitability".¹ This modernization program ensures that the submarines remain capable and available to maintain a vital undersea warfighting capability. However,

¹ Commodore Christopher Robinson, "RCN Undersea Warfare Future Capability and Challenges" Keynote Address, Deep Blue Forum, October 2020.

Canada will soon require a new class of submarine if it wishes to remain relevant among the ranks of those countries with submarines. The process to determine desired capabilities and requirements for a new submarine class should commence immediately, in a proactive fashion.

Canada benefits from a professional, modern, and effective submarine force. Submarines represent unique platforms that provide advantages in naval conflict and for coastal surveillance because they are versatile, stealthy, and deadly. Navies carefully consider deploying maritime assets to waters where submarines may be operating. The stealth of modern submarines strengthens their lethality. A submarine is an unrivalled strategic asset capable of exercising sea control, containing and defeating enemy forces, gathering vital intelligence, and enhancing the anti-submarine warfare (ASW) capabilities of allied navies. A modern, capable, and lethal submarine force is necessary to protect Canada, and support its interests abroad.

Literature Review

Royal Canadian Navy historian Jason Delaney contends that the history of submarine procurement in Canada has never been about the best submarine for Canada, but rather, it is about maintaining a submarine force.² Delaney argues that all submarine procurement programs since the end of the Second World War are rooted in the same place and have transitioned nearly seamlessly from one program to the next. Each procurement program has sought the same outcome – to *maintain* a submarine capability in Canada because, as Delaney argues, having a submarine force is the point.

² Lieutenant Jason M. Delaney, “Submarine Procurement and the *Victoria*-Class Acquisition from an Historical Perspective: Having Submarines is the Point!” *Canadian Naval Review*, Volume 4, Number 2, (Summer 2008), 22.

The history of Canadian submarines reinforces the narrative that the country maximizes the use of its maritime assets and employs them for a long time. Despite this historical pattern of resourcing, Canada must soon initiate a process to determine a replacement option for the *Victoria* class. Today, the global security environment, led by American-backed Western institutions since the end of the Second World War, is challenged with “an increasing number of state and non-state actors exercis[ing] influence”.³ The return of great power competition merits consideration due to the modernization and proliferation of submarines in the fleets of strategic challengers, namely China and Russia. Global submarine proliferation, coupled with the anti-access area-denial (A2/AD) strategy in China’s frontier, demonstrates that now is not the time for Canada to divest its subsurface capability if it wishes to remain operationally relevant. Canada requires a modern and capable submarine force to replace the *Victoria* class to meet its continental and overseas commitments, and to reassure the United States - its ally and main economic partner.

Canada has a long history of operating submarines. Since the provincial government of British Columbia purchased two submarines from a Seattle builder at the outbreak of the First World War to guard its west coast against German raiders, Canada has commissioned 15 submarines into service.⁴ The first two submarines, His Majesty’s Canadian Ships (HMCS) CC 1 and CC 2, sailed from Esquimalt throughout the war’s early stages. In 1917, the two boats were the first two Canadian warships to transit the

³ Department of National Defence, *Strong, Secure, Engaged: Canada’s Defence Policy*, (Ottawa, DND Canada, 2017), 50.

⁴ Government of Canada, “Canadian Submarine History”, Canada.ca. Government of Canada June 14, 2017. <https://www.canada.ca/en/navy/services/history/canadian-submarine-history/canadian-submarine-history.html>. Accessed 4 March 2021.

Panama Canal as they sailed from Esquimalt to Halifax.⁵ From Halifax, the two boats sailed for the Mediterranean theatre where they served until the Armistice of 1918. The submarines were paid off following the war.

Until the 1960s, the RCN only commissioned four additional submarines: two British H class boats and two captured German U-boats, one of which was transferred to the Americans in reparations, by the Tripartite Naval Commission.⁶ To supplement the capabilities of these vessels, the RCN maintained its submarine prowess by sending Canadian officers and crew to sail in Royal Navy (RN) submarines. In fact, Canadian officers commanded more than two dozen British submarines during the two world wars.⁷

In 1961, Canada leased its first Cold War submarine from America, an ex-United States Navy (USN) *Balao* class submarine re-named HMCS *Grilse*. *Grilse* sailed extensively, and was replaced with an American *Tench* class submarine after seven years of service. HMCS *Rainbow*, *Grilse*'s replacement, was named for one of Canada's first warships. *Rainbow* served in the RCN's Pacific Fleet until 1974.

In 1953, the RCN commenced the process of obtaining Canada's next class of submarine with the creation of the Submarine Committee of the Naval Staff.⁸ Over a span of several years, the committee considered what capabilities a new Canadian submarine force should have. The Canadian government finally settled on a force of three conventional British submarines, which Canada received between 1965 and 1968.⁹ The

⁵ Ibid.

⁶ Ibid.

⁷ Ibid.

⁸ Marc Milner, *Canada's Navy: The First Century* (Toronto: University of Toronto Press, 1999), 226.

⁹ Ibid, 226-231.

Oberon class submarines, or O-boats, as they were commonly referred to, were the first new submarines Canada accepted into service since British Columbia's purchase of CC 1 and CC 2. Canada's three O-boats – HMC Ships *Ojibwa*, *Onandaga*, and *Okanagan* - formed the First Canadian Submarine Squadron based in Halifax. The O-boats underwent a mid-life refit in the 1980s, and continued to sail until the late 1990s. The Royal Canadian Navy paid off the final boat, *Onandaga*, in 2000.¹⁰

Seeking a replacement for the O-boats, Canada once again engaged with the Royal Navy. In 1998, Canada reached an agreement with the United Kingdom to purchase four *Upholder* class submarines. The first of the new boats, HMCS *Victoria*, arrived in Canada two years later. Once in Canada, the submarines underwent an extensive process of 'Canadianisation', which upgraded the fire control, weapons systems, and communications suite.

Today, *Victoria* class submarines are capable and effective platforms, able to operate at sea and effectively control the sea approaches to Canada.¹¹ However, like all warships, the boats are maturing gracefully. The *Victoria* class modernization (VCM) portfolio of capital projects will enable the vessels to extend their service into the late 2030s. The project is upgrading platform and combat systems to increase operational effectiveness, while improving habitability for crew.¹² The perfect platform for continental defence, former Commander of the Royal Canadian Navy Vice-Admiral (retired) Mark Norman explained that a modernized *Victoria* class would be "the ultimate

¹⁰ Government of Canada, "Canadian Submarine History".

¹¹ Commodore Christopher Robinson, "RCN Undersea Warfare Future Capability and Challenges" Keynote Address, Deep Blue Forum, October 2020.

¹² Ibid.

guarantor of [Canada's] maritime sovereignty.”¹³ A modern submarine force is vital for safeguarding Canadian interests at home and abroad.

There is some disagreement amongst specialists as to whether Canada needs a submarine force. In a report entitled “That Sinking Feeling: Canada’s Submarine Program Springs a Leak” published jointly by the Canadian Centre for Policy Initiatives and the Rideau Institute, Michael Byers and Stewart Webb argue that the *Victoria* class procurement was a “fiasco” for a host of reasons such as mechanical and combat systems failures and poor general construction.¹⁴ Although ostensibly written to spark debate, the paper suggests that the key outcomes Canada operates a submarine force to achieve - such as maintaining submarine expertise, deterrence of maritime conflict, Arctic patrol and sovereignty assertion, and training of allied and national anti-submarine forces - are either able to be fulfilled by other means or simply not required. Further, the paper suggests that as other nations, namely Denmark, have divested their submarine capability, it is possible for Canada to do so as well. Denmark is part of the European Union, and shares security concerns with Germany, which operates a sizeable submarine force. They suggest that the Government’s failure to include the *Victoria* class submarine replacement in the National Shipbuilding Procurement Strategy (the precursor to the National Shipbuilding Strategy), is due to either “secret” government decisions or mismanagement.¹⁵

Multiple naval experts have responded to Byers and Webb’s piece. Former Canadian naval officer and naval analyst, Ken Hansen, responded in the *Canadian Naval*

¹³ Ibid.

¹⁴ Michael Byers and Stewart Webb, “That Sinking Feeling: Canada’s Submarine Program Springs a Leak,” (Ottawa: Canadian Centre for Policy Alternatives, 2013), 10-13.

¹⁵ Ibid, 6.

Review, arguing that Byers and Webb applied “insufficient academic rigour” in the development of their arguments.¹⁶ Hansen refutes Byers and Webb’s suggestion that the National Shipbuilding Procurement Strategy omission of submarines indicates a secret decision on behalf of the Government. He contends that the strategy was a “bottom-up solution to a national strategic problem” to solve the difficulty with a “boom and bust” shipbuilding industry.¹⁷ Due to the nature of submarine construction, including the *Victoria* class replacement in the strategy would not contribute to this goal because “it would not help create the stable demand industry needs to avoid the boom and bust cycle”.¹⁸ Further, Hansen refutes the arguments put forth by Byers and Webb that Canada could eliminate its submarine force altogether. Their report fails to grasp the importance of a national submarine capability, he argues, noting its vital roles in countering a submarine threat, and in training Canadian and allied maritime forces in anti-submarine warfare. Hansen is not alone in his views of the Byers and Webb report.

Paul Mitchell, a professor of defence studies at the Canadian Forces College, sought to correct “the evident errors of fact and judgment” in Byers and Webb’s report in a paper released by the Canadian Defence & Foreign Affairs Institute.¹⁹ Mitchell divides his report into two sections: the first section refutes the factual errors within *That Sinking Feeling*; and the second section counters the arguments made by Byers and Webb, and advocates that a Canadian submarine force is vital for the defence of Canada. Mitchell acknowledges problems with the *Victoria* class procurement. Specifically, the challenges

¹⁶ Ken Hansen, “A Review of ‘That Sinking Feeling: Canada’s Submarine Program Springs a Leak’”, *Canadian Naval Review*, Volume 9, Number 2 (2013), 22.

¹⁷ *Ibid*, 23.

¹⁸ *Ibid*, 23.

¹⁹ Paul T. Mitchell, “Full of Holes: Byers and Webb on Canada’s Submarine Programme” (Calgary: Canadian Defence & Foreign Affairs Institute, 2013), 1.

were associated with the procurement of an orphan class of four boats, without the necessary replacement parts.²⁰ However, he counters any arguments that the *Upholder* class was poorly constructed and that the procurement itself was flawed. Next, Mitchell addresses the argument that Canada does not need submarines. Although he concedes that the true worth of a weapons system is ultimately proven during military conflict, Mitchell argues that the history of successes in submarine operations sufficiently supports the value of a submarine force.²¹ A submarine is cheaper than a frigate, has fewer crew, and is more deadly.

Jeffrey Collins argues in a Naval Association of Canada Niobe Paper that submarines offer “unique and vital capabilities” for Canada that are difficult to replicate with any other weapons system.²² Collins notes that Canada needs a submarine force for its “deterrence, [Intelligence, Surveillance, and Reconnaissance] ISR, and alliance benefits” during littoral operations, and also for defence ambitions in the Arctic.²³ Ultimately, Collins argues that the retention of a submarine capability in Canada is not only desirable but necessary. He projects three options for renewing this capability: building the *Victoria* class replacement under the National Shipbuilding Strategy; buying overseas off-the-shelf; or undertaking a collaborative build with a foreign partner. More recently, Collins has argued that it is difficult to buy off the shelf naval vessels that adequately meet the unique requirements of Canada in a “challenging global operational environment”, noting that German submarines are designed for short range missions in

²⁰ Ibid, 12.

²¹ Ibid, 12.

²² Jeffrey Collins, “Towards a Renewed Canadian Submarine Capability” *Niobe Papers*, No. 4 (July 2019), 10.

²³ Ibid, 5-7.

shallow waters, such as the Baltic Sea.²⁴ The quality of the boat may be excellent, but it may not meet the unique requirements of a national submarine force. If Canada is serious about upholding its continental security commitments, supporting alliance and partner nations in defending the rules-based international order, and addressing international security threats, then a modern and capable submarine force remains critical.

Global Security Environment

Canadian security and defence relies on the strength of Canada's bilateral relationship with the United States, its position within the NATO alliance, and the rules-based international order. Canada and the United States share a highly connected and integrated political, military, social, diplomatic, and economic relationship, on a shared continent. American military strength protects Canada by virtue of this relationship and the shared natural geography of the two nations. American leadership within the liberal international order benefits Canada immensely. Today, however, American economic and military power is in relative decline.²⁵ The waning of American strength, relative to rising and resurgent powers around the world, should be a warning to Canada. Canadian leadership decisions on matters of national defence and foreign policy, including composition of the Canadian Armed Forces, could affect Canada's place in future international orders.

The American superpower relies on allies like Canada. The U.S. military is still the world's pre-eminent force, but the modern global environment is increasingly competitive. Adversaries challenge American military supremacy across traditional

²⁴ Jeffrey F. Collins, "In Defence of Canadian Shipbuilding." *Macleans.ca*, March 5, 2021. Accessed April 16, 2021. <https://www.macleans.ca/opinion/in-defence-of-canadian-ship-building/>

²⁵ Cooley, Alexander and Daniel H. Nexon, "How Hegemony Ends: The Unraveling of American Power" *Foreign Affairs*, Volume 99, Number 4, (July/August 2020), 144.

warfare domains at sea, on land, and in the air, and contest U.S. supremacy in emerging warfare domains of cyber and space. Former U.S. National Security Advisor for Strategy, Nadia Shadlow, argues that American freedom of action across all domains of warfare is limited due to the proliferation of new weapon technologies amongst America's primary geopolitical rivals.²⁶ China and Russia have developed A2/AD strategies and weapons that challenge America's ability to operate in nearby littoral environments.²⁷ America's military advantage is eroding around the globe as regional adversaries emerge to challenge its power. In this environment, the stealth provided by submarines is very useful. The ability to discretely and persistently provide intelligence, surveillance, and reconnaissance in an adversary's littorals is a unique capability resident within a submarine. In wartime, a submarine lurking in an enemy's littorals could act as an important link in a chain of sensors and shooters, and could contribute to joint operations or even land attack.

The relative power of emerging and resurgent powers will increase as American power declines. Today, China dominates East Asia and the influence of its power is expanding. Projections predict that China will become the world's largest economy before the end of the 21st century.²⁸ Concurrently, Russia's influence is expanding throughout Eurasia and the Middle East, displacing American power in those regions.

²⁶ Nadia Shadlow, "The End of American Illusion: Trump and the World as It Is" *Foreign Affairs*, Volume 99, Number 5, (September/October 2020), 38.

²⁷ Ibid, 38; Dan Drezner, Ronald R. Krebs, and Randall Schweller "The End of Grand Strategy", *Foreign Affairs*, Volume 99, Number 3, (May/June 2020), 109; Oriana Skylar Mastro, "The Stealth Superpower: How China Hid Its Global Ambitions", *Foreign Affairs*, Volume 98, Number 1, (January/February 2019), 33.

²⁸ Global Affairs Canada "Address by Minister Freeland When Receiving Foreign Policy's Diplomat of the Year Award." Canada.ca. Government of Canada, June 14, 2018. <https://www.canada.ca/en/global-affairs/news/2018/06/address-by-minister-freeland-when-receiving-foreign-policys-diplomat-of-the-year-award.html>; Ruchir Sharma, "The Comeback Nation: U.S. Economic Supremacy Has Repeatedly Proved Declinists Wrong" *Foreign Affairs*, Volume 99, Number 3, (May/June 2020), 80.

Importantly for Canada, the Arctic is emerging as an area of great power competition, with both Russia and China, who have increased their presence in the region.²⁹ As an Arctic nation, Canada must remain vigilant about activity in the high North. Submarines and autonomous underwater vehicles (AUVs) offer Canada platforms to assert sovereignty over the region. Submarines also offer a medium power nation - such as Canada - an outsized opportunity to generate strategic effects for itself, and in support of its allies, as a forward-deployed capability. This capacity will be even more relevant for Canada if American power continues to decline.

America spends more money on its military than any other nation. In fact, the American government spends more money on its military capability than the next seven highest spending countries combined.³⁰ Additionally, it maintains an unsurpassed system of military bases throughout the globe.³¹ Accordingly, it may seem strange to contemplate the decline of American power. However, Daniel Nexon and Alexander Cooley contend that America's rivals offer an alternative concept of global order, which threatens American power around the world.³² Russia and China have created BRICS (Brazil, Russia, India, China, and South Africa), a political institution that promotes alternative countries to the vanguard of global leadership and offers alternatives to traditional, multi-lateral, Western-controlled institutions. Similarly, China and Russia have created regional security organizations, such as the Collective Security Treaty

²⁹ Rebecca Pincus, "Three-Way Power Dynamics in the Arctic," *Strategic Studies Quarterly* 14, no. 1 (Spring 2020). <https://search-proquest-com.cfc.idm.oclc.org/docview/2393076781?pq-origsite=summon>

³⁰ "Defense Spending by Country (2020)." Global Firepower - World Military Strength. Accessed November 11, 2020. <https://www.globalfirepower.com/defense-spending-budget.asp>.

³¹ Global Firepower, "Defense Spending by Country (2020)." Global Firepower - World Military Strength. Accessed November 11, 2020. <https://www.globalfirepower.com/defense-spending-budget.asp>.

³² Alexander Cooley and Daniel H. Nexon, "How Hegemony Ends: The Unraveling of American Power" *Foreign Affairs*, Volume 99, Number 4, (July/August 2020), 147.

Organization and the Shanghai Cooperation Organization, which drain influence from the traditional Western security apparatus that buttresses American power. Finally, economic organizations, such as the Eurasian Economic Union and the Asian Infrastructure Investment Bank, challenge American-backed institutions like the International Monetary Fund. These alternative organizations “allow their members to affirm common values and boost the stature of powers that convene these forums,” effectively facilitating formation of regional alliances and diminishing the hegemonic authority of the United States.³³ Amidst these tectonic challenges to the global system, proliferation of modern weapons technology heightens the challenge faced by Western military forces. One of the most prevalent examples is global proliferation of modern submarines in regions of strategic consequence to Canada, such as Asia and the Middle East. In these regions, states challenging Western leadership are arming themselves with capable submarines, lethal and difficult to detect.

Global Submarine Proliferation

Despite a deteriorating global security environment, Canada confronts few direct threats. However, potential adversaries are renewing and modernizing submarine forces. Submarine proliferation affects regional stability, and challenges traditional Western dominance in the maritime domain. Since the fall of the Soviet Union, there are fewer submarines in total numbers around the world.³⁴ However, more countries operate submarines now than during the Cold War. Further, many Cold War submarines were merely forces-in-being, with no real combat capability or seaworthiness. The end of the

³³ Ibid, 149.

³⁴ James Clay Moltz, "Global Submarine Proliferation: Emerging Trends and Problems," Nuclear Threat Initiative Issue Brief, March 2006. Accessed 4 March 2021. <https://www.nti.org/analysis/articles/global-submarine-proliferation/>.

Cold War has resulted in an increased amount of combat power actually available beneath the surface.³⁵ The three most active submarine exporting nations are France, Germany, and Russia. Primary submarine producers in France and Germany currently export proven submarine designs with enormous capability to more than 20 national navies.³⁶ Ships (including submarines) formed the greatest share of all German arms exports from 2014–18.³⁷ The importance of a strong Canadian maritime strategy, structured around a modern submarine force, is vital to Canada’s relevance as an ally. Russian submarines are exported to China, India, Vietnam, and Iran.³⁸ Recently, China agreed to export submarines to Pakistan, Thailand, and Bangladesh.³⁹ Submarines are now flooding regions of Canadian strategic importance, such as the Asia Pacific. The ability to operate a capable submarine service is vital to Canadian interests in these regions and to maintaining stability in Canadian waters.

Today, the world’s navies operate over 500 submarines, primarily within a nation’s territorial waters and Exclusive Economic Zone.⁴⁰ Estimates suggest that within the next 15 years, over 300 more submarines will inhabit the oceans.⁴¹ Not only will this result in a greater number of submarines at sea, but also, it infers that navies are renewing

³⁵ Commodore Christopher Robinson (Commander Canadian Submarine Force, 2017-2019) in discussion with the author, April 2021.

³⁶ Nuclear Threat Initiative, “Submarine Proliferation Resource Collection.” Nuclear Threat Initiative - Ten Years of Building a Safer World, December 16, 2020. <https://www.nti.org/analysis/reports/submarine-proliferation-overview/>.

³⁷ Pieter D. Wezeman, Aude Fleurant, Alexandra Kuimova, Nan Tian, and Siemon T. Wezeman. “Trends in International Arms Transfers, 2018.” Stockholm International Peace Research Institute. Accessed March 4, 2021. <https://www.sipri.org/publications/2019/sipri-fact-sheets/trends-international-arms-transfers-2018>.

³⁸ Nuclear Threat Initiative, “Submarine Proliferation Resource Collection.” Nuclear Threat Initiative - Ten Years of Building a Safer World, December 16, 2020. <https://www.nti.org/analysis/reports/submarine-proliferation-overview/>.

³⁹ Ibid.

⁴⁰ Global Firepower, “Submarine Fleet Strength by Country (2021).” Global Firepower - World Military Strength. Accessed March 4, 2021. <https://www.globalfirepower.com/navy-submarines.asp>.

⁴¹ Jan Joel Andersson, “The Race to the Bottom: Submarine Proliferation and International Security,” *Naval War College Review*, Vol. 68, No. 1 (2015), 14

submarine fleets with newer, modern submarine technologies. These submarines are capable of exploiting new technology to remain submerged for longer periods of time, while remaining difficult to detect, and boasting greater surface and sub-surface attack power.

Responding to a Changing Global Landscape

The international system that has administered global peace and security for the past eight decades is changing. American power enables global stability that, in turn, enables Canadian sovereignty, and access to markets. Emerging and resurgent great powers are displacing Western leadership around the globe, and contributing to challenges. Submarine proliferation indicates that other nations are reinvesting in defence capacities with specific interest in national submarine capabilities. If Canada is to remain relevant and credible in the world order, it must reinvest in a modern and capable submarine fleet, or what naval expert James Boutilier refers to as the “coin of the realm”.⁴²

A modern and capable submarine force is a vital, strategic asset for maritime nations such as Canada. It is impossible to know with certainty where the Royal Canadian Navy will next fight. However, it is clear that submarines are central to the RCN’s force structure. They offer unmatched lethality, and provide a vital link in a chain of sensors and weapons systems affording Canada a measure of sea control at home and abroad. Submarines offer a significant, and often disproportionate, strategic and tactical advantage in any naval conflict. *Canada in a New Maritime World: Leadmark 2050*

⁴² Senate of Canada, *Reinvesting in the Canadian Armed Forces: A Plan for the Future*, (Canada, Standing Senate Committee on National Security and Defence, 2017), 36.

signals the RCN's aspirations for a Blue Water naval force. The framework for a Blue Water navy, as outlined in *Leadmark 2050*, analyzes required and desired capabilities for a *Victoria* class replacement. A boat that fits the Blue Water vision of the RCN will be significantly more capable than Canada's current submarine flotilla.

The Canadian Armed Forces must be ready for any mission the Government of Canada assigns. A deteriorating global security environment, coupled with the proliferation of modernized submarines in regions of strategic consequence for Canada, yields a situation where it is prudent to plan for an ongoing Canadian submarine requirement. As the history of Canadian submarine operations has demonstrated, it is difficult to regain a submarine capability once it has been divested. If Canada were to enter a maritime conflict without a submarine capability, it is unlikely that such competence would be regained by the conflict's end. A modern, capable, and lethal submarine force is essential to defend Canada, and support national strategic objectives.

CHAPTER 1: WHY CANADA NEEDS SUBMARINES

Canada aspires to have a navy of a certain rank, to reflect its standing and ambitions as a strong middle power. The submarine remains a key asset in maintaining that status. A submarine force is indicative of a mature and capable fighting navy. While surface ships offer valuable contributions to warfighting, naval diplomacy, and support to other governmental departments, submarines are mission-oriented platforms. In wartime, a submarine sits in a defined box and kills any adversary who enters. A submarine offers serious offensive threats to an enemy. Even the potential presence of an un-located submarine creates a tactical and operational challenge for an opponent. Canada needs a submarine force to control access to its maritime approaches, counter enemy maritime forces, conduct ISR, train allied anti-submarine (ASW) forces, and provide Canadian maritime forces with *strategic weight*.

Exerting Sea Control

Submarines are a specialized warfighting platform that exert sea control. Julian Corbett, the great British seapower theorist, argued that the “object of naval warfare must always be directly or indirectly either to secure the command of the sea or to prevent the enemy from securing it.”⁴³ Contested command of the sea is its natural state, according to Corbett. Command must be asserted and defended. Through control of the sea, a state ensures rights of passage upon global commons. If a sea power truly retains command of the seas, that country also maintains unhindered maritime communications across the seas and can deny those same advantages to an enemy. By denying an enemy safe passage on the seas, a sea power state may “check the movement of his national life at

⁴³ Julian Stafford Corbett. *Principles of Maritime Strategy*. Mineola (NY): Dover Publications, 2004, 87.

sea in the same kind of way we check it on land by occupying its territory.”⁴⁴ By winning and maintaining command of the sea, a seapower removes restrictions on maritime movement. Further, a sea power may exert “military pressure upon the national life of our enemy ashore” while preventing an enemy from “exerting direct military pressure upon [its own nation].”⁴⁵ The simplified objective of naval warfare is to control maritime communications for commercial or naval purpose.⁴⁶ Bordering three oceans, Canada’s preferred weapon for achieving sea control in this vast amount of water is the submarine and torpedo carrying maritime aircraft.⁴⁷ Submarines can control choke points in sea approaches to Canada, or support allied or coalition forces overseas. A submarine does not need to be everywhere, just within its assigned patrol box at a key choke point.

Sea control may be general or local. General sea control is the monopolization of the sea by a prominent naval power, or determined upon the outcome of a decisive naval victory that has swept the seas clean of rival sea powers.⁴⁸ Local sea control is possible if a sea power does not wield a capacity to enforce its will upon all rival sea powers concurrently, but is sufficiently strong to control a portion of the communication routes it values. Localized sea control is temporal, as a rival sea power that enjoys command of the sea can focus its efforts to overthrow a sea power that is only capable of regional sea control. Geoffrey Till argues that sea power “can be seen as a tight and inseparable system in which naval power protects the maritime assets that are the ultimate source of

⁴⁴ Julian Stafford Corbett, *Principles of Maritime Strategy*, Mineola (NY): Dover Publications, 2004, 89-90.

⁴⁵ *Ibid*, 90.

⁴⁶ *Ibid*, 90.

⁴⁷ Department of National Defence, *Canada in a New Maritime World: Leadmark 2050*, (Ottawa, DND Canada, 2015), 39.

⁴⁸ Corbett, *Principles of Maritime Strategy*, 100.

its prosperity and military effectiveness.”⁴⁹ The RCN’s submarine force affords Canada a measure of localized sea control in Canada’s maritime approaches, and a potential to temporarily seize control of strategic waterways abroad in support of alliance or coalition operations.

Submarines are critical platforms for controlling the seas.⁵⁰ A submarine can detect and sink enemy submarines, surface combatants, and shipping, all while remaining undetected. The presence, or suspected presence, of a submarine will influence an enemy’s planning process in an operational theatre, and is vital in controlling or denying an adversary’s access to the sea.⁵¹ For example, when the British nuclear attack submarine HMS *Conqueror* sunk the Argentine cruiser ARA *General Belgrano* during the 1982 Falklands war, the remaining Argentine surface fleet returned alongside until the war was over out of fear that the undetected RN vessel would continue to attack and sink assets. With a single action, the Royal Navy established limited control of the South Atlantic theatre.⁵² Interestingly, two Argentine diesel submarines, present in the same conflict, preoccupied British anti-submarine forces all through the remainder of the campaign.⁵³ The Royal Navy fired over 200 torpedoes at suspected submarine contacts throughout the war, demonstrating how the perception of an enemy submarine adds prudence to any surface fleet’s operations. For a relatively small force like the RCN, the

⁴⁹ Geoffrey Till. *Seapower a Guide for the Twenty-First Century*. Abingdon, Oxon: Routledge, 2018, 17

⁵⁰ Department of National Defence, *Canada in a New Maritime World: Leadmark 2050*, (Ottawa, DND Canada, 2015), 39.

⁵¹ Department of National Defence, *Canada in a New Maritime World: Leadmark 2050*, (Ottawa, DND Canada, 2015), 39.

⁵² Scot Macdonald, "The Falklands Campaign: The British Reconquest and the Argentine Defense." *Marine Corps Gazette* 84, no. 3, 2000, 72.

⁵³ *Ibid*, 73.

ability to employ submarines into a theatre of operations, as part of a coalition or alliance, projects a formidable threat with an outsized tactical and strategic effect.

Countering Enemy Submarines

The most effective anti-submarine weapon is another submarine. Submarines are the premier means to detect, track, classify, and attack adversarial submarines, while simultaneously remaining undetected. Countries are making considerable investments in submarines. Today, more countries operate sophisticated and modern submarines than ever before.⁵⁴ Due to proliferation of submarines throughout the world, a serious submarine capability is increasingly vital as a means to counter these threats. Further, while traditional submarine operating nations continue to maintain subsurface fleets, they also continue to export submarines to regions of strategic Canadian importance, particularly in Asia and Latin America.⁵⁵ For instance, China has determined that submarines are the most significant maritime assets of this century, due to their lethality and inherent stealth.⁵⁶ Russia continues to rebuild its submarine fleet with modern, capable vessels.⁵⁷ Further, great-circle maritime transit routes between Asia and the key ports on the west coast of North America travel through Canada's North American Aerospace Defence Command (NORAD) area of responsibility. This increases the

⁵⁴ Jan Joel Andersson, "The Race to the Bottom: Submarine Proliferation and International Security," *Naval War College Review*, Vol. 68, No. 1 (2015), 15.

⁵⁵ *Ibid*, 14.

⁵⁶ Lieutenant Commander Jamie A. Clarke, "China's Naval Modernization in the Mahanian Mirror: Reconsidering Real Force Capacity in the Medium and Longer-Term Perspective", Canadian Forces College, Directed Research Project, April 2008, 31.

⁵⁷ David Axe, "The Russian Navy's Growing Submarine Fleet Is Ready To Contest NATO Waters." *The National Interest*. The Center for the National Interest, October 1, 2020. <https://nationalinterest.org/blog/reboot/russian-navys-growing-submarine-fleet-ready-contest-nato-waters-169923>. Accessed 4 February 2021.

likelihood of a Chinese or Russian submarine presence off Canada's west coast.⁵⁸ In this geopolitical environment, a capable Canadian submarine force is crucial to countering threats posed by adversarial submarines. Without submarines, Canada is left wide open.

Countering Enemy Surface Combatants

Submarines are deadly anti-surface warfare (ASuW) weapons. In Admiral Sergei Gorshkov's book, *The Sea Power of the State*, the former Soviet admiral argues that submarines "form a considerable counter-balance to the main forces of the fleet of our enemy."⁵⁹ The *Victoria* class submarines are outfitted with "highly sensitive acoustic, electro-optic and electromagnetic sensors, as well as the world's most advanced bow sonar", which "detect and track surface vessels at great distance" while remaining concealed.⁶⁰ In these conditions, a submarine maintains the initiative by choosing the time and place of a hostile engagement. During the 1982 Falklands campaign, HMS *Conqueror* detected, identified, and commenced tracking ARA *General Belgrano* on May 1st. *Conqueror* tracked *Belgrano*, undetected, for over a day before receiving orders from London to attack the Argentine warship.⁶¹ The advantage afforded to *Conqueror* allowed the RN to maintain the initiative, retain freedom to manoeuvre, and attack on its own terms. Capable and modern submarines influence the actions of enemy combatants, and provide friendly surface forces defence in depth by sanitizing water columns for allied use. Surface combatants are mere targets for a submarine. The presence, or possible

⁵⁸ Commodore Christopher Robinson (Commander of Canadian Submarine Force 2017-2019) in discussion with the author, February 2021.

⁵⁹ Sergei G. Gorshkov, *The Sea Power and the State*, (Malabar, Florida: Robert E. Krieger Publishing Company Inc., 1979), 190.

⁶⁰ Department of National Defence, *Canada in a New Maritime World: Leadmark 2050*, (Ottawa, DND Canada, 2015), 40.

⁶¹ Lawrence Freedman, *The Official History of the Falklands Campaign, Volume 2: War and Diplomacy* (London: Routledge, Taylor & Francis Group, 2005), 289.

presence, of a Canadian submarine that operates in associated or direct support of the surface fleet provides a credible deterrent and increases the safety of all friendly maritime forces in the area.

Conducting Intelligence, Surveillance, and Reconnaissance

Modern submarines are exceptional ISR assets. As such, this represents their actual day-to-day employment in most navies. A superb combination of endurance and stealth allows submarines to operate where other maritime assets are exposed. A submarine can execute a wide array of intelligence collection techniques throughout multi-domain theatres, including the littorals, and combined with land, air, space and cyber surveillance assets, establish a complete understanding of the operational environment as a “key element of the system-of-systems approach to maritime domain awareness”.⁶² A conventional submarine with decent sensors under reasonable environmental conditions can search an area significantly larger than a surface warship while remaining unobserved.⁶³ In an A2/AD environment, a submarine’s ability to operate in an enemy’s littorals makes it “a proven and invaluable tool in collecting ISR data”, including the ability to “detect high frequency, very high frequency and ultra-high frequency signals and cellphone transmissions.”⁶⁴ Submarines are not solely valuable from an intelligence collection standpoint. Operating submarines also permits Canada access to underwater information collected by allies.

⁶² Commodore Christopher Robinson (Commander of Canadian Submarine Force 2017-2019) in discussion with the author, February 2021.

⁶³ Jeffrey Collins, “Towards a Renewed Canadian Submarine Capability” *Niobe Papers*, No. 4 (July 2019), 4.

⁶⁴ *Ibid*, 4.

As a submarine operating nation, Canada maintains access to valuable underwater intelligence. As a NATO member and close American ally, Canada retains access to water space information and is privy to intelligence gleaned from underwater arrays and sensors.⁶⁵ Canada participates in the global water-space management program, which de-conflicts the movements of allied submarines from partner nations in an effort to avoid unexpected friendly interactions beneath the surface. These agreements provide Canada with access to extensive underwater information, otherwise unattainable if Canada did not maintain a submarine capability.

Training Allied Anti-Submarine Forces

RCN submarines are excellent assets that provide Canadian allies with valuable ASW training opportunities. As a diesel electric submarine service, Canadian boats are highly coveted training platforms used to train the United States Navy (USN). The USN does not operate diesel electric submarines but potential adversaries do – in particular, Iran.⁶⁶ Therefore, the *Victoria* class is a favoured platform for ASW exercises with the USN and other allied navies.⁶⁷ Canadian participation in complex ASW exercises also provides valuable benefits for enhancing Canadian warfighting capacity, while enhancing the ASW proficiency of partner nations.

Providing Canadian Maritime Forces with *Strategic Weight*

A submarine is a strategic national asset ensuring that Canada can exercise sovereignty throughout its Exclusive Economic Zone (EEZ), while supporting the rules-

⁶⁵ Ibid, 4.

⁶⁶ Ibid, 4.

⁶⁷ Editor, “Canadian Submarines Conduct Successful Deployments.” *Lookout Newspaper*, December 5, 2018. <https://www.lookoutnewspaper.com/canadian-submarines-conduct-successful-deployments/>. Accessed 27 January 21.

based international order at sea throughout the world. Former Chief of the Royal Australian Navy, Vice Admiral (Retired) Ray Griggs, argued that a capable submarine force gives the state who wields it a “strategic weight”.⁶⁸ A modern submarine force “shapes or changes the behaviour of other nations and the calculus of their leaders” in a way no other CAF asset does.⁶⁹ A submarine’s capacity to influence an adversary’s behaviour was apparent during Canada’s dispute over the turbot fishing industry with Spain in 1995. Canada issued a “Notice of Intention” for a submarine to operate off the Grand Banks during the diplomatic impasse.⁷⁰ The threat that a Canadian submarine may operate near the disputed area caused Spain to reassess its position and led to eased tensions between the two nations.

Further, lethal and multi-role submarines are unique platforms that offer unprecedented benefits in maritime disputes. Submarines are covert and deadly. A single torpedo, accurately fired from a submarine, will sink most vessels below a certain size. Consequently, navies are wary of deploying ships into a maritime theatre where adversarial submarines could operate. The stealth offered by modern and capably operated submarines strengthens this hazard. *Canada in a New Maritime World: Leadmark 2050* asserts: “Submarines are likely to remain the dominant naval platform for

⁶⁸ Vice Admiral Ray Griggs, “The Role of Submarines in a Maritime Strategy,” Chief of Navy Speeches, 9 April 2014. Accessed 25 January 21. <http://www.navy.gov.au/media-room/publications/chief-navyspeeches-april-2014>, 7-8.

⁶⁹ Vice Admiral Ray Griggs, “The Role of Submarines in a Maritime Strategy,” Chief of Navy Speeches, 9 April 2014, 7-8. <http://www.navy.gov.au/media-room/publications/chief-navyspeeches-april-2014>. Accessed 25 January 21.

⁷⁰ Paul T. Mitchell, “The Deal of the Century: Canada’s Problematic Submarines in Historical Perspective,” Laurier Centre for Military Strategic and Disarmament Studies, 28 June 2013.

the foreseeable future, and hence are an essential component of a balanced combat-effective navy.”⁷¹

Lastly, a modern and capable submarine force is the ultimate strategic capability, short of a nuclear weapon. Submarines control the seas, contain and defeat opposing naval forces, and conduct other vital tasks, including capacity building and intelligence collection with allied assets. For Canada’s navy, a submarine is the ultimate force multiplier warfighting platform.

⁷¹ Department of National Defence, *Canada in a New Maritime World: Leadmark 2050*, (Ottawa, DND Canada, 2015), 50.

CHAPTER 2: CAPABILITIES FOR A CANADIAN SUBMARINE

REPLACEMENT

The *Victoria* class submarines are capable and effective platforms. However, they are maturing gracefully and in need of a proactive replacement plan. A flotilla of four submarines is barely sufficient for continental defence, and insufficient to effectively patrol Canadian waters *and* contribute to collective defence measures abroad. The *Victoria* class modernization project is upgrading the platform's combat sensors and hotel services, such as fresh water and ventilation, allowing Canada to operate the platform for at least one more operational cycle (9 years per submarine).⁷² Commodore Christopher Robinson, former Commander of the Canadian Submarine Force, observes that life extension for the *Victoria* class shall necessitate replacement in the mid-2030s.⁷³ It is improbable but possible that the boats will be operated years longer. If the *Oberon* class is any measure, the *Victoria* class platforms will be operated well beyond their credible service lives. When considering a replacement for the *Victoria* class, however, Canada should seek to improve its submarine capability rather than simply replace the resident capabilities.

Originally designed as the *Upholder* class, the *Victoria* class were built for operations in the North Atlantic waters surrounding the United Kingdom and Greenland during the Cold War. The geopolitical environment and expected submarine mission have evolved. Likewise, the threats to Canada and the international system Canada depends upon have also evolved. Given the timeline for complex defence procurement in Canada,

⁷² Commodore Christopher Robinson (Commander of Canadian Submarine Force 2017-2019) in discussion with the author, April 2021.

⁷³ Commodore Christopher Robinson, "RCN Undersea Warfare Future Capability and Challenges" Keynote Address, Deep Blue Forum, October 2020.

it would be a failure not to improve Canada's submarine capability and best position Canadian maritime forces for future operating environments. The considered capabilities for its next class of submarines should contribute to a balanced, combat-effective, multi-purpose, survivable, adaptable and agile submarine force, capable of being forward deployed in support of strategic objectives.

Strategic documents published by Canada's Department of National Defence are instructive in this analysis. *Strong, Secure, Engaged: Canada's Defence Policy* (SSE) communicates Canada's aspirational strategic objectives for its navy: "Canada requires a Navy that is organized and sized to project power responsively and effectively far from Canada's shores."⁷⁴ This navy will enable "joint action ashore and support the sustainment of joint operations from sea, while preserving the ability to defend its own freedom of action through naval combat operations" as either a single ship independent deployer or as a member of a task group.⁷⁵ Submarines are a vital component of the Canadian Naval Task Group, which enables the RCN to project power at some distance from Canadian shores and contribute to partner and alliance operations. Flowing from SSE, the Royal Canadian Navy's *Canada in a New Maritime World: Leadmark 2050* details future requirements and potential threats. *Leadmark 2050* advocates for a forward postured submarine, able to control sea-lanes of communication and maritime choke points, enforce Canadian sovereignty, and deter conflict.⁷⁶ The ultimate theme in these

⁷⁴ Department of National Defence, *Strong, Secure, Engaged: Canada's Defence Policy*, (Ottawa, DND Canada, 2017), 34.

⁷⁵ *Ibid*, 35.

⁷⁶ Department of National Defence, *Canada in a New Maritime World: Leadmark 2050*, (Ottawa, DND Canada, 2015), VI, 28.

strategic documents is that a modern submarine force is essential to a balanced, dispersed, fighting naval force.

In line with the RCN's vision for a Blue Water navy, the future Canadian submarine force must be multi-purpose and multi-present. In order to achieve these objectives, the *Victoria* class replacement must retain and expand upon a number of capabilities. Increased ISR collection, deterrence, warfighting capacity, and an ability to operate while remaining undetected are self-evident requirements. However, the future Canadian submarine force should also be able to operate in the high North, contribute to joint operations in the littorals – including long range precision fires, remain connected to naval and joint networks while submerged and transiting, insert and extract special operations forces, and operate autonomous underwater vehicles. In order to meet the defence challenges of the coming decades, *Leadmark* envisions a Blue Water submarine fleet that is balanced, combat-effective, survivable, and multi-purposed. This globally deployable force must be capable of long ocean crossings and of operating anywhere in the world, including Canada's Arctic. This aspirational vision foresees a submarine fleet that is operated and sustained in a way that allows Canadian submarines to be forward deployed, routinely and persistently to regions of Canadian strategic concern.

The RCN must pursue each of these capabilities in a *Victoria* class replacement platform. While the *Victoria* class is ideally suited for continental defence, Canada has demonstrated a desire to deploy submarines abroad in support of alliance and coalition efforts supporting strategic objectives. These overseas deployments have had severe repercussions on maintenance and readiness for the *Victoria* class flotilla, effectively resulting in a year long operational pause following the tandem deployment of a

Canadian submarine to Europe while concurrently deploying a second submarine to the Asia Pacific region. This suggests that there is a greater desire to employ the *Victoria* class abroad than is currently possible. These inherent desires and strategic needs must be front of mind in considering the future of the Canadian submarine force.

Balance

A modern submarine fleet is an important component of a balanced naval force structure. The Canadian submarine force provides vessels capable of:

... unrivalled stealth, persistence and lethality [that] can place an adversary's maritime forces at risk in a given theatre of operations through offensive action. They can also amplify the defence in depth of the surface forces they are assigned to protect. They remain the most effective means to counter an adversary's submarine force and can operate where surface combatants would be placed at great risk.⁷⁷

Submarines are the single most important platform in the RCN's order of battle.

Currently, the four *Victoria* class submarines meet the role for which they were intended, mainly exerting sea control in Canada's sea approaches. However, considering maintenance cycles, four boats does not provide much flexibility for employment. The RCN should consider how many submarines it requires to meet the availability requirement of the Canadian submarine force.

The number of submarines available for employment determines the RCN submarines' force readiness. Generally speaking, if a nation has three submarines, one will be in deep maintenance, one will be in short-term maintenance, and the third will be available for operations. Naval policy analyst Jan Joel Andersson supports the viability of the "rule of threes", suggesting that four submarines will permit one or two boats

⁷⁷ Department of National Defence, *Canada in a New Maritime World: Leadmark 2050*, (Ottawa, DND Canada, 2015), 39.

availability for operations, with the remainder being used for crew training or undergoing maintenance.⁷⁸ If a fleet of six submarines replaced the *Victoria* class, it is reasonable to assume that four would be operational at any time, with three boats available for tasking. This would allow one submarine to perpetually operate on each of Canada's East and West coasts, and in the Arctic when viable. This reflects Canada's strategy with regard to the size of the *Harry DeWolf* class Arctic and Offshore Patrol Vessels (AOPVs), the RCN's newest class of ship. With a fleet of six AOPVs, the RCN will be able to operate one ship continuously in both the Atlantic and Pacific Oceans, while surging two additional ships into the high North during the summer navigable season. A greater availability rate would necessitate a larger submarine fleet.

The option to maintain a Canadian submarine on each of Canada's coasts, combined with the option to have one submarine available for overseas operations, would necessitate that more than six submarines are required. Australia is currently building 12 new *Attack* class submarines based on the French Barracuda, a conventional version of a big nuclear boat. The Royal Australian Navy (RAN) determined that with 12 submarines, Australia would maintain four boats consistently available for operations, with a surge capacity in time of crisis.⁷⁹

Previous Canadian White Papers and operational experience regularly assesses that Canada needs more submarines than it currently operates.⁸⁰ As far back as 1953, the RCN began to consider options for a new submarine fleet, creating the Submarine

⁷⁸ Jan Joel Andersson, "The Race to the Bottom: Submarine Proliferation and International Security," *Naval War College Review*, Vol. 68, No. 1 (2015), 17.

⁷⁹ Marcus Hellyer, "Why Does Australia Need 12 Submarines?" Australia Strategic Policy Institute: The Strategist, November 18, 2020. <https://www.aspistrategist.org.au/why-does-australia-need-12-submarines/>.

⁸⁰ Jeffrey Collins, "Towards a Renewed Canadian Submarine Capability" *Niobe Papers*, No. 4 (July 2019), 9.

Committee of the Naval Staff to contemplate possibilities.⁸¹ After five years, the Naval Staff determined that a fleet of six nuclear and six conventional submarines would satisfy capability requirements of the era. However, the Government determined that three conventional British submarines were sufficient.⁸² The RCN received three *Oberon* class submarines, which would be operated by Maritime Command for the next three decades.

In the 1980s, when Canada's three *Oberon* class submarines were showing their age, the Mulroney government wanted to purchase 12 nuclear attack submarines to replace the aged fleet. That plan met considerable resistance and eventually the Canadian navy and a new Liberal government settled for four near new but mothballed British *Upholder* class submarines, renamed the *Victoria* class.⁸³ At present, the *Victoria* class submarines are thirty years old and undergoing a modernization program to preserve operational capacity until the 2030s.

In 2017, the Standing Senate Committee on National Security and Defence released a report entitled *Reinvesting in the Canadian Armed Forces: A Plan for the Future*. In that report, the committee recommended an aspirational goal that Canada should procure 12 modern submarines and divide the force evenly between the Atlantic and Pacific fleets.⁸⁴ Such numbers would enable the RCN's continuous employment of three submarines on both the East and West Coasts, and provide boats, as required, for Arctic and expeditionary operations.

⁸¹ Marc Milner, *Canada's Navy: The First Century* (Toronto: University of Toronto Press, 1999), 226.

⁸² *Ibid*, 226-231.

⁸³ Jeffrey Collins, "Towards a Renewed Canadian Submarine Capability" *Niobe Papers*, No. 4 (July 2019), 2-3.

⁸⁴ Senate of Canada, *Reinvesting in the Canadian Armed Forces: A Plan for the Future*, (Canada, Standing Senate Committee on National Security and Defence, 2017), 37-38.

No doubt submarines are essential to a balanced naval force. While continuous employment of submarines in each ocean is key, it is important to note that the RCN requires additional subsurface platforms to enable completion of other assigned tasks. Those missions could span the full spectrum of naval operations, from benign humanitarian efforts and ISR, to kinetic warfighting. For the force to be truly balanced, each fleet must have a readily available submarine force to execute assigned missions.

Combat-Effective

Canada's future submarine fleet must also be combat effective across all domains of naval warfare. A replacement submarine for the *Victoria* class must be "able to contribute to operations ashore and be highly interoperable with Canada's allies and defence partners."⁸⁵ A new submarine fleet must be able to control Canada's maritime approaches. Additionally, it must capably integrate with allies on operations, conducting tasks ranging from presence and surveillance missions to traditional anti-surface, anti-submarine, littoral operations and long-range precision fires.

A capable, combat-effective submarine force is a valuable deterrent, and useful in both defensive and offensive roles. In both ASW and ASuW roles, a modern submarine utilizes the basic characteristics of "endurance, stealth, freedom of movement and versatility" to position itself appropriately to strike, or threaten a strike.⁸⁶ These enabling characteristics allow the submarine to unleash a torpedo at enemy submarines or surface vessels alike. Such weapons must be fully integrated into the submarine's combat management system, which must be able to communicate with other national and allied

⁸⁵ Department of National Defence, *Canada in a New Maritime World: Leadmark 2050*, (Ottawa, DND Canada, 2015), VI.

⁸⁶ Peter Haydon, "Canada and Modern Submarines." *Canadian Naval Review* 12, no. 1 (2016), 35.

combat systems in a network of sensors, processing equipment, and kinetic weapons systems. To this end, the submarine must be able to prioritize targets and contribute to an integrated maritime campaign.

Beyond traditional combat operations, a modern Canadian submarine is ideally suited to contribute to littoral operations. Monitoring an adversary's port facility, deploying and extracting special operations forces, providing intelligence for counter-trafficking operations, and contributing to joint targeting ashore are missions that Canada's submarine force should expect to execute in future maritime operations. Jeffrey Collins, a Canadian defence policy analyst, argues that in the modern A2/AD landscape, such as the Asia Pacific and Middle East, a submarine's ability to operate in the littorals will be of increasing importance as nations tend not to easily risk surface ships in an A2/AD environment.⁸⁷ Canada's current submarine fleet has no surface-to-surface missile capability, which Collins notes as a capability amongst other allied nations such as Australia. These countries employ the use of surface launched submarine missiles to amplify the depth of organic anti-surface warfare units and increase resident fleet capability.⁸⁸ An anti-surface missile, similar to the Harpoon used in the RCN's *Halifax* class frigates, would support Canada's system-of-systems approach to maritime operations, and provide a fleet commander a greater range of options when considering offensive measures. Moreover, a Canadian submarine with the ability to employ a land-attack missile system, such as the Tomahawk land-attack missile, would allow a

⁸⁷ Jeffrey Collins, "Towards a Renewed Canadian Submarine Capability" *Niobe Papers*, No. 4 (July 2019), 7.

⁸⁸ *Ibid*, 7.

submarine to attack targets ashore while remaining submerged, providing precision fires from an undetected location.

The concept of long-range precision fires has been deemed a future capability for the RCN. Since 2016, the RCN has been conducting annual exercises to develop expertise in the joint targeting cycle, by firing Harpoon missiles from *Halifax* class frigates at static targets ashore. The Government of Canada has announced that the *Halifax* class replacement, the Canadian Surface Combatant (CSC), will employ the Kongsberg naval strike missile, which can engage targets at sea or on land.⁸⁹ The CSC will also be equipped with the Raytheon Tomahawk land-attack missile, specifically designed for long-range precision fires.⁹⁰ Either of these missile technologies, or a similar capability, employed in a future Canadian submarine, would provide Canada with a deeper range of tactical and strategic options when engaging land targets at extended ranges. Low Frequency Active (LFA) submarine hunting ships also need to be engaged at ranges well beyond what a submarine launched torpedo can achieve.

Canada's future submarine fleet must be combat-effective, able to sink ships and submarines, and deter enemy action. In order to achieve this aim, the *Victoria* class replacement must be able to conduct essential submarine tasks, including anti-surface and anti-submarine warfare in the littorals, and should be able to integrate into allied and partner operations.

⁸⁹ Kongsberg, "NSM – Naval Strike Missile – Missile Systems." Kongsberg. Accessed March 2, 2021. <https://www.kongsberg.com/kda/products/defence-and-security/missile-systems/nsm-naval-strike-missile-nsm/>; and Naval Technology, "Projects Archive - Naval Technology." Naval Technology. Accessed March 2, 2021. <https://www.naval-technology.com/projects/canadian-surface-combatant/>.

⁹⁰ Government of Canada, "Canadian Surface Combatants." Department of National Defence, Royal Canadian Navy, February 18, 2021. Accessed March 1, 2021. <http://www.navy-marine.forces.gc.ca/en/fleet-units/csc-home.page>.

Multi-Purpose

In addition to being combat-effective, a modern Canadian submarine must also be able to gather information and intelligence covertly, and effectively communicate that data across national and international communication infrastructures. To achieve the Canadian government's defence ambitions defined in SSE, the RCN must exploit multi-purpose platforms. Canada's next submarine must be able to operate across the spectrum of operations at sea, while integrating with "national and international defence and security partners among government and civil society."⁹¹

Canada's future submarine fleet would ideally boast the most modern ISR technology available. This equipment, including sonar and other sensors, enables operators to understand and assess their environment above and below the surface. This capability is not only essential to the safety of the submarine and its crew but also vital to building a wider intelligence picture that shapes broader operations. However, simple information collection does not enable operations. The collected data must be rapidly transferrable to an appropriate authority for synthesis and use.

The *Victoria* class replacement should possess a communications suite that enables liaison with other maritime units and higher headquarters, while remaining submerged and underway. Without this capability, the vital characteristics of a submarine – stealth, mobility, and endurance – are diminished. The communication systems should transmit data collected by the submarine's organic sensors in order to fulfill a "key element of the system-of-systems approach to maritime domain awareness".⁹² In this

⁹¹ Department of National Defence, *Canada in a New Maritime World: Leadmark 2050*, (Ottawa, DND Canada, 2015), VI.

⁹² Commodore Christopher Robinson (Commander of Canadian Submarine Force 2017-2019) in discussion with the author, February 2021.

way, a submarine can contribute to a pan-domain surveillance system, and amplify the utility of a single unit within a broader system of networks.

A submarine is a multi-purpose platform. A small navy like the RCN is likely to maintain but a single class of submarine. Therefore, it is important that the submarine is able to perform all the vital functions deemed necessary by the Government of Canada. Determination of these capabilities will come from close engagement between the RCN, the Canadian Armed Forces, the Department of National Defence, and Cabinet, to define necessary and aspirational ambitions for the Canadian submarine force.

Arctic-capable

Victoria class submarines have operated north of the Arctic Circle throughout their service lives and will continue to do so periodically. In 2007 and 2009, HMCS *Corner Brook* deployed to the Canadian Arctic; while HMCS *Windsor* operated north of the Arctic Circle in 2016.⁹³ When ice conditions are favourable, the *Victoria* class can safely operate in the high North or in the chokepoint approaches to the Northwest Passage.⁹⁴ As temperatures in the region increase, the operating window in this area will lengthen. The level of under-ice capability this next class of Canadian submarine will have will determine Canada's strategic ability to shape maritime operations in the Arctic.

As the region warms, more traffic will transit waters within Canada's Exclusive Economic Zone. SSE envisions an RCN that is able to operate in all three Canadian oceans, alongside the Canadian Coast Guard and its ice breaking capability, and enforce Canadian sovereignty in each region. As climate change grants more shipping access to

⁹³ Marcello Sukhdeo, "The Capabilities and Challenges of Canada's Future Fleet: Interview with Commodore Christopher Robinson, Director General Naval Force Development, Royal Canadian Navy", *Vanguard Canada*, (October/November 2020), 22.

⁹⁴ *Ibid*, 22.

the Northwest Passage and changes the transit route of shipping traffic throughout the globe, Canada's Arctic is expected to witness an exceptional increase in associated maritime activity. The importance of ensuring sovereignty and surveillance of this region will increase in tandem.

There are two types of Arctic submarine patrols: those conducted under the ice, and those conducted near the edge of the ice, in the area defined as the Marginal Ice Zone (MIZ). Each type of Arctic environment affords specific challenges but different types of submarines are required to operate in each environment, depending on the desired capability. A conventional diesel electric submarine, such as the *Victoria* class, can operate near the MIZ but cannot safely operate underneath solid ice. Similarly, a submarine with Air Independent Propulsion (AIP) can operate near ice but would be limited in its ability to conduct under-ice patrols. As AIP technology advances, however, it is conceivable that within the service life of the *Victoria* class replacement, this technology may facilitate under-ice operations.⁹⁵

The ability to conduct sustained under-ice operations remains an endeavor suited only for nuclear powered submarines with the ability to create their own air and water and break through the ice's surface with the size and strength of its hull.⁹⁶ The Government of Canada's requirement determination for under-ice submarine operations will help define the propulsion plant in a new class of Canadian submarine. In addition to

⁹⁵ Jeffrey Collins, "Towards a Renewed Canadian Submarine Capability" *Niobe Papers*, No. 4 (July 2019), 6.

⁹⁶ Marcello Sukhdeo, "The Capabilities and Challenges of Canada's Future Fleet: Interview with Commodore Christopher Robinson, Director General Naval Force Development, Royal Canadian Navy", *Vanguard Canada*, (October/November 2020), 22.

the challenge of under-ice operations, other unique challenges to Arctic submarine operations must be considered.

Commodore Christopher Robinson highlights three specific challenges to operating in the high North: navigation, distance from support, and environmental protection.⁹⁷ These concerns must be addressed if the RCN intends to operate the next class of Canadian submarines in the Arctic.

Safe navigation is a paramount concern for the safety of any seagoing vessel and its crew. In a submarine, it is important to navigate with accurate charts denoting the area's bottom soundings. In the Arctic, bottom soundings are poorly charted. As such a submarine's sensor suite becomes vitally important in the avoidance of navigation hazards.

The second challenge Commodore Robinson highlights regarding Arctic submarine operations is the prohibitive range from support services. Canada does not have any accessible Arctic shipyards for submarines that suffer an engineering catastrophe. Canada's Arctic naval port, the Nanisivik Naval Facility, consists of a jetty with a refueling capability. There is no resident support for warships with engineering troubles. Moreover, the Nanisivik Naval Facility is further from Halifax than Portsmouth, United Kingdom, and further from Esquimalt than Tokyo, Japan.⁹⁸ These sheer distances present a significant challenge to Arctic operations.

Lastly, the environmental challenges of Arctic operations must be considered. The *Arctic Water Pollution Prevention Act* pertains to environmental protections for Canada's Arctic waters. During peacetime, Canadian warships must adhere to regulations within

⁹⁷ Ibid, 22.

⁹⁸ Ibid, 22.

the Act that concern expulsion of bilge water and organic waste from vessels.⁹⁹ These constraints must be considered as Canada intends to continue operating submarines in the Arctic. Since a submarine conducting sustained operations in the high North will be constrained by these regulations, it is of greater importance that they either have the capacity to hold greater amounts of waste, or be able to sufficiently clean it before jettisoning it back into the ocean.

The Royal Canadian Navy has ambitions to operate a submarine force in Canada's Arctic. Thus, the next class of Canadian submarine must meet certain requirements. The submarines must be appropriately designed to safely navigate near or under Arctic ice, at a long distance from support, while considering the unique environmental aspects of the Arctic. The dangers of under ice operation are significant, and must be carefully considered. Autonomous underwater vehicle technology presents an opportunity to obtain similar results under the ice, with significantly less risk to life. The ability to utilize cutting edge AUV platforms, with a Canadian submarine operating in the MIZ as a mothership, presents an opportunity.

Even if the process of procuring the *Victoria* class replacement fleet commenced presently, at least a decade would pass before the next class of submarines joined the RCN. The Arctic environment is increasingly amenable to naval operations. Further, based on historical evidence, it is likely the next Canadian submarine will remain in the Canadian order of battle for upwards of four decades. The Arctic environment will continue to evolve over this period and maritime activity in the high North will continue to increase. Naval and defence planners must project themselves forward into this

⁹⁹ Ibid, 22.

potential future operating environment when considering Canada's future submarine requirements. The fleet must be Arctic-capable.

Globally Deployable

A globally deployable submarine fleet is one that can cross oceans and operate with logistical support for missions of extended duration around the globe. For a western state such as Canada, this means that a submarine must be able to operate with significant endurance. The *Victoria* class offers Canada a limited ability to deploy its submarine force overseas. However, given the future security environment, Canada's next class of submarines should be capable of operating further abroad for sustained periods. Given the challenges to the rules-based international order at sea, the ability to deploy a capable submarine into an adversary's littorals will provide a significant strategic impact for Canada and its allies.

Endurance will be of immense importance for a Canadian submarine assigned missions overseas, in support of Canadian strategic objectives, and even domestically. Whether transiting to the Asia-Pacific, Europe, or Latin America, or even sailing to the high North, Canadian submarines will have to endure long transits and remain on patrol for periods of a month or more to be effective. Endurance relates to the propulsion system a submarine uses. Generally, there are three types of submarine propulsion systems: nuclear powered, diesel electric, and air independent propulsion.

Of these submarine types, nuclear powered submarines are the fastest, boasting the greatest endurance. Further, nuclear submarines can safely operate under Arctic ice. However, their large size and constantly operating reactor cooling systems cause increased noise that reduces audible stealth when compared to conventional counter-

parts. Ultimately, nuclear powered submarines are less effective for operation in the littorals where their acoustic signatures make them particularly vulnerable to detection.¹⁰⁰

Conversely, diesel electric submarines enjoy an increased level of stealth but are slow in comparison to nuclear submarines. They owe their stealth to the relative quietness of the batteries that power their propulsion system while submerged. However, they must snorkel to cycle fresh air into their machinery plant and charge batteries fairly frequently. Additionally, diesel submarines are constrained in range by the amount of fuel they can carry. Consequently, a conventional diesel submarine could refuel and resupply in theatre, but doing so would compromise the submarine's stealth and crew security.¹⁰¹ Further, their refueling requirement would decrease Arctic capability.

The last option is an AIP system, which enables a non-nuclear submarine to operate without access to oxygen from the atmosphere for prolonged periods.¹⁰² AIP technology uses pressurized liquid oxygen to remain submerged for much longer periods than those afforded to diesel electric submarines. Rather than being constrained by battery life, the endurance of an AIP enabled submarine is limited by its stores of pressurized liquid oxygen.¹⁰³ Careful operation of an AIP system is vital to ensure that pressurized liquid oxygen is not depleted, forcing the submarine to switch to the conventional diesel electric system and negating the benefits of the AIP system.¹⁰⁴

¹⁰⁰ Hans J. Ohff, "Nuclear Versus Diesel-electric: The Case for Conventional Submarines for the RAN," Australian Strategic Policy Institute: The Strategist, 11 July 2017. Accessed March 4, 2021.

<https://www.aspistrategist.org.au/nuclear-versus-diesel-electric-case-conventional-submarines-ran/>.

¹⁰¹ Peter T. Haydon, "Canada's Future Submarine Capability" Navy League of Canada (July 2004). Microsoft Word - Submarine Paper _long version_.doc (navyleague.ca).

¹⁰² Norman Jolin, "Future Canadian Submarine Capability: Some Considerations", *Canadian Naval Review*, Volume 11, No. 1, (2015), 17.

¹⁰³ Ibid, 17.

¹⁰⁴ Ibid, 17.

Due to Canada's size, endurance is an important consideration for a future submarine force charged with patrolling three oceans and the world's longest coastline. A nuclear submarine enjoys limitless endurance, and the capacity to travel at high speeds although suffering from the drawback of decreased relative stealth. Conventional diesel electric submarines and AIP enabled submarines provide stealthier options for a submarine fleet. Yet, both platforms are constrained in range due to their requirement to carry fuel or pressurized liquid oxygen. Further, neither AIP enabled nor conventional submarines are able to transit around Canada's vast maritime expanses, or across the Pacific or Atlantic Oceans at high speeds.

Canada is blessed with an allied superpower to its south and three vast ocean expanses on its other three borders. Whether patrolling Canadian waters, or deploying overseas, Canadian submarines will have to transit significant distances to arrive in operational theatres. To be a globally deployable and remain effective in operations, Canada's modern submarine force will require substantial endurance.

Forward-postured

A forward-postured submarine force operates and sustains itself abroad, so that it may remain deployed to regions of strategic value. This requires chains of communication, maintenance, and supply. Specifically, a forward-postured submarine must consider its own storage capacity, fuel capacity, battery life, and routine maintenance requirements.

To maintain a forward-postured submarine force, Canada must consider the requirements that enable a submarine to maintain a forward presence. Storage capacity will determine how much food and supplies the submarine can embark. In turn, this will

determine how often the submarine's crew must resupply. Similarly, the vessel's fuel capacity will determine how often the submarine must refuel. While some submarine designs permit at-sea refueling, many do not. The design of the submarine will determine if at-sea refueling is possible, or whether the boat must return alongside. If refueling is conducted at sea, support infrastructure and personnel are required to fill this logistical task. Finally, battery life determines how often a submarine must return to periscope depth to snorkel, which may reveal its position. If the submarine is operating in littorals, recharging its batteries could threaten the mission and the safety of the crew.

A replacement for Canada's *Victoria* class must be designed to operate in a forward-deployed posture if it is to be an effective tool projecting military power abroad. Given the great distances separating Canada from the locations of its strategic interests, consideration of key constraints, such as fuel, stores, and battery life are vital. Designing Canada's modern submarine fleet with these factors in mind will enable Canadian submarines to operate abroad for longer durations. While greater battery sizes may increase propulsion endurance, that advantage is offset by the requirement for larger engines to avoid lengthy snorting times.¹⁰⁵ Likewise, greater fuel capacities require larger fuel tanks and more storage capacity means larger stores rooms. These considerations have the potential to increase the size and weight of a submarine, which will cause a corresponding decrease in speed, range, and endurance.¹⁰⁶ A strategic balance between

¹⁰⁵ Janis Cocking, Christopher Davis and Christopher Norwood, "Australia's Requirement for Submarines" Australian Government, Department of Defence Science and Technology Group, 2016. Accessed 4 March 2021. <https://www.dst.defence.gov.au/publication/australias-requirement-submarines>, 8.

¹⁰⁶ Janis Cocking, Christopher Davis and Christopher Norwood, "Australia's Requirement for Submarines" Australian Government, Department of Defence Science and Technology Group, 2016. Accessed 4 March 2021. <https://www.dst.defence.gov.au/publication/australias-requirement-submarines>, 8.

propulsion capability, internal space for fuel, crew, equipment and weapons is required for Canada's modern submarine fleet to be forward-postured.

Survivable

Canada's next submarine fleet must operate in a variety of unforgiving environments, and be able to sustain and recover from substantial damage. Submarine survivability refers to many variables, including hull strength, stealth and speed.

A strengthened hull is a vital characteristic of submarine survivability. Operating in Canada's Arctic waters requires a hardened outer casing to guard against ice or uncharted bottom features. If the submarine must break through ice, then hull strength and overall submarine size will also be an important factor.¹⁰⁷ If damage compromises the submarine's hull, compartmentalization is vital to ensure the maintenance of watertight integrity while the submarine transits to a safe harbour to affect repairs.

A submarine's stealth is a necessary component of its survivability. While a submarine remains undetected, it is safe from attack. Once a submarine is detected, however, it becomes vulnerable. The best defence against an adversarial attack is to remain undetected. To achieve this, a submarine must be quiet and retain the endurance to remain submerged for long periods. Stealth is enabled by various means, including anechoic tiling that absorbs sound on the submarine's outer hull and within the submarine's pressure hull to reduce emitted equipment noise.

Finally, speed is another essential component of submarine survivability. Once detected, a submarine's best course of action is to evade its enemy as rapidly as possible

¹⁰⁷ Marcello Sukhdeo, "The Capabilities and Challenges of Canada's Future Fleet: Interview with Commodore Christopher Robinson, Director General Naval Force Development, Royal Canadian Navy", *Vanguard Canada*, (October/November 2020), 22.

to avoid being tracked, classified, and attacked. In most circumstances, speed is vital to quickly create distance from the enemy. Further, if a submarine is attacked, speed becomes critical to evading inbound torpedoes. In many instances, a submarine's speed - while evading an attack - may mean the difference between life and death for the submarine's crew.

In line with Canada's vision for a Blue Water navy outlined in *Leadmark 2050*, the replacement for the *Victoria* class submarine will patrol the maritime approaches to Canada and may deploy overseas periodically. Designing and building a survivable submarine is important to safeguarding Canada's submarine crews, and the submarines themselves, which are vital strategic assets.

Adaptable and Agile

Future maritime operations will be complex. Canada requires an adaptable and agile submarine force to compete in such an environment. This force should be able to adapt to new technological innovations, including the ability to launch, operate, and recover AUVs. Further, while not an absolute requirement, ability to insert and extract special operations forces (SOF) is a worthwhile capability that will increase flexibility and relevance of a submarine force, and provide the Canadian government with ISR and kinetic options in future warfare environments without committing traditional forces.

The next class of Canadian submarine should be able to launch, operate, and recover AUVs. AUVs are versatile and able to complete dangerous tasks formerly assigned to crewed-vehicles or humans. Whether employed for route-survey, to "locate underwater mines, carry out itemized searches... obtain bottom feature imagery," or used as a remote mine-hunting and disposal system, AUVs will permit a "full spectrum of

naval mine hunting operations and contribute to underwater domain awareness”.¹⁰⁸ A future submarine must have the flexibility to exploit AUV technology as it advances and new equipment becomes available. This multi-purpose capability enables a future submarine force to adapt to future innovations and remain on the leading edge of new warfare tools.

In terms of technological adaptability, a modern submarine force should contemplate the capacity to insert and extract special operations forces. The ability to employ SOF from a submarine is a force multiplier, permitting an undetectable method of placing kinetic forces ashore. To be effective in this capability, the submarine must have a mechanism to launch special operators, equipment, and insertion craft from a submerged lockout to maintain an undetected posture. Although it is possible to do this while the submarine is surfaced, doing so would place the submarine and the inserting operators at risk. Beyond a submarine’s ability to insert SOF assets, logistical and mechanical requirements must be considered to ensure this capability’s viability. SOF personnel will occupy valuable space in submarines while transiting to and from the embarkation point. The necessary equipment for SOF operations will also occupy limited storage space in the vessel. Moreover, if there is a desire to employ this capability at short notice, SOF units must routinely train and practice with the submarine to ensure safe and timely disembarkation and embarkation from the boat while it remains submerged.¹⁰⁹ Being able to insert and extract SOF from the littorals of an adversarial

¹⁰⁸ Commodore Christopher Robinson, “RCN Undersea Warfare Future Capability and Challenges” Keynote Address, Deep Blue Forum, October 2020.

¹⁰⁹ Peter T. Haydon, “Canada’s Future Submarine Capability” Navy League of Canada (July 2004). Microsoft Word - Submarine Paper_long version_.doc (navyleague.ca), 34.

nation is a useful strategic capability, and one that adds to the versatility of the submarine.

A future submarine force must be adaptable and agile. It must be prepared to operate in complex future maritime operations. The force must adapt to new technological innovations, including the ability to launch and recover AUVs and possibly SOF personnel. Further, the next generation of Canadian submarine must be flexible enough to incorporate new technology when delivered, so that it may maintain a competitive edge in future operations.

The *Victoria* class submarines are modernized, with at most two decades of service life remaining. By the mid-2030s, they will require replacement by a new class of Canadian submarine for Canada to maintain this vital maritime capability. Whichever design is selected as the replacement, it must be a submarine that can operate unrestricted on at least two of Canada's coasts, and occasionally on the third, as well as operate in areas of strategic national importance periodically. It must also be able to integrate into highly sophisticated national and international networks and act as a link in a sensor chain that can provide the Canadian government with strategic options, while providing defence in depth for friendly maritime forces.

CHAPTER 3: CANADIAN SUBMARINE PROCUREMENT OPTIONS

With the exception of two captured U-boats during the Second World War, all of Canada's submarines have been obtained from the United States or United Kingdom. Each of those submarines have previously served in the Royal Navy or United States Navy. However, Canadian submarine requirements are not fully in tune with British or American requirements, and neither nation continues to build conventional diesel-electric submarines. Canada requires a submarine force to control Canadian waters, counter adversarial maritime forces, and collect intelligence. It must be capable of surveillance and reconnaissance missions, a useful training partner for friendly forces and provide Canada with an element of *strategic weight*. Further, a future Canadian submarine force must have the ability to operate in the Canadian Arctic, deploy to theatres of Canadian importance, and support joint operations in the littorals. It must remain connected to joint networks while submerged and underway, launch and recover special operations forces, and operate un-crewed underwater vehicles.

Several submarine procurement options support these requirements. The determination of procurement options is directly related to the determination of the vessel's propulsion plant. Propulsion plant options include nuclear and non-nuclear boats, and vessels that operate with AIP systems. These must be examined while an analysis of procurement options is pursued. Namely, there are three options for procurement: building submarines in Canada under the National Shipbuilding Strategy (NSS) or its successor; collaborating with a foreign partner; or purchasing a proven submarine from overseas.

The Nuclear Option

Canadian submarines require great endurance. Canada has the world's longest coastline and is bordered by three vast oceans. A Canadian submarine must travel great distances across the Pacific and Atlantic Oceans, and operate in the high North, far away from support facilities and refueling stations. The only propulsion source capable of unlimited endurance is nuclear powered.

Nuclear submarines are the only crewed platform capable of operating for prolonged periods under ice. Diesel electric and AIP submarines can operate near the edges of the ice, but are at risk operating in deep waters under solid ice. Only nuclear submarines have the necessary power to repeatedly surface through thick ice.¹¹⁰ To replenish air, conventional submarines must approach the surface and raise a snorkel, which is an impossible feat under thick ice. Nuclear submarines create their own air, and are not required to return to the surface to replenish oxygen levels in their atmosphere.

Operating a nuclear submarine fleet is the only means by which Canada can signal its ability to exert sovereignty over all of Canada's waters. A nuclear submarine can travel under the ice of the Northwest Passage from the Pacific to the Atlantic in half the time it would take to make the trip through the Panama Canal.¹¹¹ Further, Canada's operation of a nuclear attack submarine in the Arctic would necessitate that other nations disclose to Canada when they operate submarines in the Canadian Arctic. Presently, there is little reason to do so, other than diplomatic courtesy. However, if Canada operates submarines under the Arctic ice cap, there is an increased risk of submarine collisions if

¹¹⁰ Administrator, "Canada's Future Submarines." *Canadian Naval Review*, September 25, 2017. <https://www.navalreview.ca/2017/09/canadas-future-submarines/>.

¹¹¹ *Ibid.*

water-space management protocols are neglected.¹¹² Further, there is currently no ability for Canada to rescue a damaged or sunk submarine in the high North. Such a disaster would be difficult for any submarine service to recover from.

Nuclear submarines are also the most expensive option and would entail development of new capabilities and infrastructure. The cost of procuring nuclear submarines is a key reason behind the failure of Canada's two previous attempts to obtain a nuclear submarine fleet. The Mulroney era attempts at procuring a nuclear fleet of submarines is instructive, as there were challenges with transferring intellectual property rights to Canada for nuclear submarine technology. Such challenges may preclude a future nuclear submarine fleet from being built in Canada. Further, such an impasse may result in Canadian nuclear submarines being maintained overseas, which could reduce their availability, and open up the RCN to operational challenges.

Non-Nuclear Submarine

A non-nuclear, blue-water submarine able to meet Canadian requirements will be large and require significant power generation capabilities.¹¹³ Traditional diesel electric submarines must routinely return to the surface to replenish fresh air into the submarine, permit power generation, and atmosphere regeneration. The process of doing so exposes the vessel to detection and attack. The diesel engines generate electricity, which is stored in large batteries. Using electricity stored in these batteries affords the boat an unparalleled level of acoustic stealth relative to using diesel engines. The batteries power

¹¹² Captain (N) Phil Webster, "Arctic Sovereignty, Submarine Operations and Water Space Management" *Canadian Naval Review*, Volume 3, Number 3, (2007), 14-16.

¹¹³ Norman Jolin, "Future Canadian Submarine Capability: Some Considerations", *Canadian Naval Review*, Volume 11, No. 1, (2015), 17.

weapons systems, propulsion motors, and life-support systems.¹¹⁴ However, diesel electric submarines must periodically raise a snorkel mast to the surface to run their diesel engines. As a result, operating a conventional diesel electric submarine under anything but the thinnest ice is impossible. AIP technology increases the amount of time that a conventional, non-nuclear submarine can remain submerged. All conventional AIP submarines, however, still rely on internal combustion engines as their primary power source. The AIP system is utilized for periods of stealth but does not grant diesel electric submarines the same range as nuclear-powered vessels.

Four main variations of AIP technology are currently available. All four variants require liquid oxygen (LOX) to operate and offer methods to achieve prolonged periods of submerged operation.¹¹⁵ As a result, a vessel is limited by its LOX storage capacity. It is foreseeable that advances in submarine battery technology and greater LOX capacity could increase the submerged capability of any AIP variant to enable limited, under-ice operations. The four AIP systems considered here are: closed cycle steam turbines; closed cycle diesel engines; fuel cells; and Stirling cycle engines.

Closed cycle steam turbines use the same steam propulsion plant as a nuclear submarine, using heat generated by burning ethanol and LOX rather than nuclear fusion.¹¹⁶ The French closed cycle steam turbine system utilizes the *Module d'Energie Sous-Marin Autonome* (MESMA) design. The MESMA system in the French *Agosta 90B* extends the duration of time a submarine can remain submerged by three times than that

¹¹⁴ Ibid, 17.

¹¹⁵ Ibid, 18.

¹¹⁶ Edward C. Whitman, "Air Independent Propulsion – AIP Technology Creates a New Undersea Threat" *Undersea Warfare*, Issue 13, (2004), 4.

of a conventional diesel electric vessel.¹¹⁷ Closed cycle steam turbines have potential to generate the most power of any AIP system, but the plant is inefficient and consumes far more oxygen than other air independent propulsion systems.¹¹⁸

Closed cycle diesel engine AIP technology has existed since before the Second World War, but has never seen use in a modern submarine.¹¹⁹ The closed cycle diesel engine AIP system creates an artificial air intake environment using LOX as an oxidant, diluted with exhaust gases, to create combustion.¹²⁰ However, the noise generated from running the diesel engine increases the risk of being detected, eliminating the stealth benefit of operating below the surface.¹²¹ Therefore, this technology is incompatible with modern submarine operations.

Fuel cells are virtually noiseless. Currently, they are the stealthiest AIP system available. This variant is also the most efficient oxygen consumer of the four air independent propulsion technologies.¹²² Fuel cells are similar to a battery, but they generate electricity by coupling LOX with hydrogen. The hydrogen and LOX is stored in tanks, and is highly flammable. The benefits of this technology are limited by the amount of LOX and hydrogen a submarine can carry. Further, this is the most expensive of the four AIP technologies.¹²³ The German made Type 212 uses the Proton Exchange

¹¹⁷ Naval Technology “SSK Agosta 90B Class Submarine.” Naval Technology. Accessed March 16, 2021. <https://www.naval-technology.com/projects/agosta/>.

¹¹⁸ Norman Jolin, “Future Canadian Submarine Capability: Some Considerations”, *Canadian Naval Review*, Volume 11, No. 1, (2015), 18.

¹¹⁹ Edward C. Whitman, “Air Independent Propulsion – AIP Technology Creates a New Undersea Threat” *Undersea Warfare*, Issue 13, (2004), 4.

¹²⁰ *Ibid*, 4.

¹²¹ Norman Jolin, “Future Canadian Submarine Capability: Some Considerations”, *Canadian Naval Review*, Volume 11, No. 1, (2015), 18.

¹²² J.B. Lakeman, and D.J. Browning, *The Role of Fuel Cells in the Supply of Silent Power for Operations in Littoral Waters*, (Gosport, UK: 2004), 47.

¹²³ Norman Jolin, “Future Canadian Submarine Capability: Some Considerations”, *Canadian Naval Review*, Volume 11, No. 1, (2015), 18.

Membrane Fuel Cell technology, and has enjoyed significant success. In 2016, a Type 212 remained submerged for three weeks, travelling 1600 nautical miles on its AIP system alone.¹²⁴ The Type 212 is a relatively small submarine, built for littoral operations. A larger, ocean going submarine using fuel cell technology could store greater supplies of LOX and hydrogen, potentially extending the submerged operating range of an AIP submarine using fuel cell technology.

Stirling cycle engines are quiet, reliable, and inspired by the external combustion engine. A Stirling cycle engine is a closed-cycle regenerative heat engine that uses energy from heated gas that is transferred into mechanical energy through pistons or turbines, to operate a generator.¹²⁵ The heat source in an AIP submarine is derived from a combustion chamber that burns liquid oxygen, diesel fuel, and an inert gas.¹²⁶ The Swedish *Gotland* class, as well as the much larger Japanese *Soryu* class, both operate a Stirling cycle engine AIP system.

Non-nuclear AIP systems cannot match the endurance or speed of a nuclear submarine. Conventional AIP submarines can achieve relatively high speeds, such as 20 knots, but only for very short periods.¹²⁷ The endurance of any of the four air independent propulsion technologies is limited to the amount of fuel that can be carried onboard. Once the LOX and other required fuels are exhausted, the submarine must rely solely on its diesel engines for power. Finally, while AIP technology may allow a submarine to

¹²⁴ LCdr Iain Meredith, “Canada’s Under-Ice Options: Submarine Air-Independent Propulsion”, Canadian Forces College Service Paper, (2018), 7.

¹²⁵ Saab, “The Secret to the World’s Most Silent Submarine: Stories: Saab” Saab, March 24, 2015. Accessed March 16, 2021. <https://www.saab.com/newsroom/stories/2015/march/the-secret-to-the-worlds-most-silent-submarine>.

¹²⁶ LCdr Iain Meredith, “Canada’s Under-Ice Options: Submarine Air-Independent Propulsion”, Canadian Forces College Service Paper, (2018), 8-9.

¹²⁷ Norman Jolin, “Future Canadian Submarine Capability: Some Considerations”, *Canadian Naval Review*, Volume 11, No. 1, (2015), 19.

operate submerged for longer periods than a conventional diesel electric submarine, AIP submarines cannot operate freely beneath the ice cap. An AIP submarine relies on LOX to regenerate oxygen without resupply from the surface atmosphere. However, if a fire were to ignite while submerged, the breathable atmosphere onboard would deteriorate quickly and the submarine would be forced to the surface to replenish air. For this reason, it remains dangerous for AIP submarines to operate deep under the ice cap.

Procurement Options

Canada has a history of buying or leasing submarines from the United States and United Kingdom. However, those countries no longer have conventional submarines. Each procurement option offers varying degrees of control over the capabilities and resident requirements within a new class of submarine, as well as challenges associated with supply chains, technical support structures, and a myriad of other considerations. Each option will be expensive but some options will be costlier. Canada's recent experiences procuring the Canadian Surface Combatant fleet highlight some of these challenges, including accurate estimate of associated costs of building technologically complex warships in Canada. Three main procurement options for the next class of Canadian submarine are: building platforms in Canada under the National Shipbuilding Strategy (NSS) or its successor; collaboration with an ally; or purchase of a proven submarine class from overseas.

Build Under the National Shipbuilding Strategy

The National Shipbuilding Strategy is Canada's concept to maintain an organic shipbuilding industry that is insulated from the 'boom and bust' cycles generally associated with that industry. The strategy, unveiled in 2010, is a thirty-year plan to

invest in the Canadian shipbuilding industry, ensuring continuous employment within the Canadian shipbuilding sector while supporting Canadian industry and strengthening Canadian supply chains. Further, this strategy aims to maintain national shipbuilding expertise and capacity, allowing Canada to surge shipbuilding during a time of war. The NSS originally established strategic relationships with Irving's shipyard in Halifax and Seaspan's shipyard in Vancouver, to build the new fleets for both the Royal Canadian Navy and the Canadian Coast Guard.¹²⁸

Since the Second World War, Canada has maintained an organic shipbuilding capacity. However, the Second World War exposed the limitations of Canada's shipbuilding ability. It became evident that Canada relied on British and American warships for all but the least sophisticated ships. Today, shipbuilding is significantly more complex than it was during the Second World War. Modern warships and submarines are amongst the most complex machines on the planet. It takes time to grow the expertise required to build modern naval craft.

The National Shipbuilding Strategy is flexible and could be expanded to include submarines. The NSS initially included two shipyards as strategic partners in 2012, but was later expanded to include Chantier Davie in Quebec, with an additional \$15.7 billion for shipbuilding projects benefitting the Canadian Coast Guard.¹²⁹ The NSS could be expanded again to incorporate a fleet of Canadian submarines.

¹²⁸ Government of Canada, "National Shipbuilding Strategy (NSS)." Shipbuilding and Industrial Marine Industry. Innovation, Science and Economic Development Canada, November 3, 2016. Accessed March 16, 2021. <https://www.ic.gc.ca/eic/site/sim-cnmi.nsf/eng/uv00050.html>.

¹²⁹ Jeffrey Collins, "Towards a Renewed Canadian Submarine Capability" *Niobe Papers*, No. 4 (July 2019), 8; and Government of Canada, "Canada Announces next Step toward Adding Third Strategic Partner under National Shipbuilding Strategy." Canada.ca. Public Services and Procurement Canada, December 19, 2019. Accessed March 16, 2021. <https://www.canada.ca/en/public-services-procurement/news/2019/12/canada-announces-next-step-toward-adding-third-strategic-partner-under-national-shipbuilding-strategy.html>.

Building submarines in Canada would minimize challenges arising from a new submarine fleet. For example, domestic submarine production would minimize supply chain issues since there would be limited reliance on foreign sources for replacement components and parts. Recently, this problem has been illustrated in Canada regarding vaccine production and a reliance on foreign states' supply chains. Building naval ships and submarines in Canada strengthens organic national supply chains and limits risk of supply chain disruption during a time of war. Building submarines in Canada also strengthens national technical expertise and reduces risk of operational disruptions from sending submarines overseas for maintenance.¹³⁰ Further, at a time when submarine proliferation is widespread, depending on the number of Canadian submarines to be built, available export countries could be burdened with construction and maintenance of their exported fleets. It follows that Canadian interests may not be prioritized. There is risk that required maintenance may be unavailable and costly. The knowledge and expertise gained from building the *Halifax* class frigates in Canada “paid off when it came to completing the equally technically challenging and costly refits here in Canada.”¹³¹ Moreover, the technical expertise gained from decades of maintenance on *Victoria* class submarines is hard earned. A new class of Canadian-built submarines would permit that knowledge to be leveraged and expanded.

Building submarines in Canada could be the most expensive option. The cost of the Canadian Surface Combatant continues to rise and construction is yet to begin on the first hull. As Canadian shipyards do not have experience building submarines, initial

¹³⁰ Jeffrey F. Collins, “In Defence of Canadian Shipbuilding.” *Macleans.ca*, March 5, 2021. Accessed March 15, 2021. <https://www.macleans.ca/opinion/in-defence-of-canadian-ship-building/>.

¹³¹ *Ibid.*

costs of establishing this capability would be very high. Canadian allies such as Australia and Spain are both recapitalizing their submarine fleets, and experiencing challenges with building the boats domestically.

Like Canada, Australia has an immense coastline, much of which is difficult to access. The Australian economy also faces fiscal pressures similar to Canada; yet, they are pushing ahead with recapitalization of their submarine fleet.¹³² This is due in part to the less advantageous geopolitical position Australia endures. Like Canada, Australia is a staunch American ally but decline of American power is felt more deeply, due to Australia's proximity to China and Asia. As one of the measures Australia is taking to deter Chinese aggression, the Royal Australian Navy is replacing its six *Collins* class submarines with 12 *Attack* class SSKs, based on the French conventional shortfin *Barracuda* design. The *Attack* class will be 4,000 tons on surface, and capable of lengthy ocean transits, joint fires, and strike missions.¹³³ There is much that should be appealing in its design for Canada. However, Australia is experiencing significant challenges with the *Attack* class program, including its troubles adapting its hull and fighting suites for U.S. weapons rather than those of European origin, modifying from a nuclear to a conventional design, and pressure from Canberra for Naval Group, the French firm which was awarded the build contract, to guarantee work in Australia over the lifetime of the agreement. Further, the *Attack* class is not Arctic capable, and does not have an AIP capability. Budget estimates for the new submarines continue to escalate, recently

¹³² Nikkei Asia, "Australian Naval Program Sums up Dilemmas for 'Middle Power' Nations," accessed April 4, 2021. <https://asia.nikkei.com/Politics/Australian-naval-program-sums-up-dilemmas-for-middle-power-nations2>

¹³³ Ibid; and Royal Australian Navy. "Attack Class SSG." Royal Australian Navy. Accessed April 4, 2021. <https://www.navy.gov.au/fleet/ships-boats-craft/future/ssg>.

reaching an estimated \$80 billion dollars for a fleet of 12 boats, up from \$50 billion five years earlier.¹³⁴

NATO member Spain is also rebuilding its submarine fleet. Spain is currently building four *Isaac Peral* class SSKs to replace its two remaining *Galerna* class SSKs. The *Isaac Peral* class are equipped with AIP, and armed with torpedoes and Harpoon missiles. It displaces 3,400 tons, and is designed for long range deployments.¹³⁵

However, Spain has experienced significant challenges undertaking this build programme domestically at the Navantia shipyard in Cartagena. The first of four submarines was intended for delivery to the Spanish Navy in 2015. However, due to ongoing technical challenges, no submarine is yet to be delivered.¹³⁶ The lesson from Australia and Spain is that domestically-built submarines will likely end up costing more and take longer to build than forecasted. With challenges come opportunity and Canada is in a stronger position than these two nations having had the opportunity to learn from their hardships with the benefit of hindsight.

Canadian geography and strategic interests are unique. Therefore, Canadian submarine requirements are unique. While investing in the establishment of a submarine producing industry could be costly, government expenditures would be domestic and support Canadian jobs and industry. Building a Canadian submarine under the National

¹³⁴ Anthony Galloway, "Defence Knew Submarines Would Cost Almost \$80b Five Years Ago." *The Age*, October 13, 2020. <https://www.theage.com.au/politics/federal/defence-knew-submarines-would-cost-almost-80b-five-years-ago-20201012-p564ea.html>.

¹³⁵ Naval News, "Navantia: Development of S-80 Submarine's AIP System Completed," accessed April 4, 2021, <https://www.navalnews.com/naval-news/2020/03/navantia-development-of-s80-submarines-aip-system-completed/>.

¹³⁶ Europa Press. "Navantia Retrasa Hasta Dos Años La Entrega Del Primer Submarino S-80 Por Problemas Técnicos." Accessed April 4, 2021. <https://www.europapress.es/economia/noticia-economia-empresas-ampl-navantia-retrasa-dos-anos-entrega-primer-submarino-80-problemas-tecnicos-20130508115530.html>.

Shipbuilding Strategy would allow Canada to build a submarine designed for its unique challenges, rather than using an existing submarine for operations for which it is ill-suited.

Collaborate with an Ally

Many Canadian allies are building submarines, or renewing submarine fleets. Australia, Japan, and Spain are all building large non-nuclear submarines that may meet Canadian requirements.¹³⁷ The Canadian government could collaborate with an ally to build a common platform. The benefits of doing so would potentially include a reduced cost per submarine when compared to producing a new class domestically. Ultimately, doing so could also increase the number of submarines acquired. However, collaboration requires compromise. Canada would lose some capability to define requirements. Further, the economic and industrial benefits of building a submarine industry domestically would be lost, and Canadian dollars would be spent overseas.

NATO allies Norway and Germany are collaborating on a common design for their next class of submarine. Norway is replacing its *Ula* class SSKs with a flotilla of four German Type 212 conventional submarines with air independent propulsion.¹³⁸ Norway's coastline borders Russia's route to the Atlantic Ocean and, as such, they assess the Russian navy to be a strategic threat.¹³⁹ Under the deal, ThyssenKrupp Marine Systems will build six AIP submarines based on the Type 212 design. The submarines will be built in Germany. Four of the boats will be delivered to the Royal Norwegian

¹³⁷ Jeffrey Collins, "Towards a Renewed Canadian Submarine Capability" *Niobe Papers*, No. 4 (July 2019), 8.

¹³⁸ Sebastian Sprenger, "German, Norwegian Officials Huddle over Joint Submarine Program." *Defense News*. Accessed April 4, 2021. <https://www.defensenews.com/global/europe/2019/04/30/german-norwegian-officials-huddle-over-joint-submarine-program/>.

¹³⁹ Norwegian Ministry of Defence, *The Defence of Norway: Capability and Readiness* (Oslo: Ministry of Defence, 2020), 8.

Navy, and two to the German Navy.¹⁴⁰ The six vessels of the U212CD (Common Design) are modernized, larger versions of the Type 212, and is estimated to cost 4.4 billion Euros.¹⁴¹ The German Navy shares many of the same strategic concerns as the Royal Norwegian Navy, making the combined design a reasonable compromise for the two nations. If Canada collaborated with an ally on design and construction, it would need to find an ally with similar strategic considerations and required submarine capabilities. There is also an opportunity to build domestically but collaborate with allies – such as Australia – to guard the NSS from the same pitfalls experienced overseas.

Buy Established Platforms

A number of Canadian allies have thriving submarine export industries. For instance, both France and Germany build and export proven submarines. However, those boats are built for different operating environments than experienced in Canada. Further, there is an unknown cost associated with Canadianising foreign submarines. Canada experienced this while procuring the *Victoria* class submarines from Great Britain. It took Canada decades to operationalize the *Victoria* class. Further, while buying a proven submarine from overseas could be cost effective, it will establish Canadian reliance on that supplying nation for maintenance, technical expertise, and the supply chain. There would be little benefit to Canadian industry or labour forces, as Canada would send its

¹⁴⁰ Sebastian Sprenger, “German, Norwegian Officials Huddle over Joint Submarine Program.” Defense News. Accessed April 4, 2021. <https://www.defensenews.com/global/europe/2019/04/30/german-norwegian-officials-huddle-over-joint-submarine-program/>; and Thomas Nilson, “Norway's New Subs Especially Designed for Covert, Shallow Water Operations.” The Independent Barents Observer. Accessed April 4, 2021. <https://thebarentsobserver.com/en/security/2021/03/norways-new-sub-esspecially-designed-covert-shallow-water-operations>.

¹⁴¹ Thomas Nilson, “Norway's New Subs Especially Designed for Covert, Shallow Water Operations.” The Independent Barents Observer. Accessed April 4, 2021. <https://thebarentsobserver.com/en/security/2021/03/norways-new-sub-esspecially-designed-covert-shallow-water-operations>.

money overseas. Additional infrastructure and maintenance capacity would be required in Canada, creating additional costs. The required expertise to support such domestic capacity could take many years to develop and create operating challenges for the new submarines. If Canada selects a proven submarine, a number submarine options are available. The best allied submarine exporting nations are Germany and France, and each have proven platforms that Canada could purchase and effectively employ. Also, the Japanese *Soryu* class is worthy of consideration here.

The German built, 1,800 ton Type 212A is a modern AIP submarine that is considered one of the premiere non-nuclear submarines in the world. The design is constantly evolving, improving sensors, communications, and habitability. In 2013, U-32, a German Type 212A remained submerged for 18 days on its AIP system.¹⁴² The cost for a single Type 212A is currently \$600 million USD.¹⁴³ This proven, economical design provides significant capability for the RCN.

The 1,600 ton French built *Scorpene* class diesel electric submarine is the best submarine on the export market, and can be fitted with AIP systems. It is armed with torpedoes, anti-surface missiles, and is capable of conducting mine laying operations. Variants of the *Scorpene* are present in the force structures of navies all around the world, including India, Brazil, Malaysia and Chile. Buyers are able to customize their submarines with different technologies, proving that the *Scorpene* is a versatile submarine export option.¹⁴⁴ India has acquired five of six *Scorpene* class SSKs, armed

¹⁴² Peter Haydon, "Canada and Modern Submarines." *Canadian Naval Review* 12, no. 1 (2016), 36.

¹⁴³ *Ibid*, 36.

¹⁴⁴ *Ibid*, 36.

with torpedoes and anti-surface missiles, for an estimated \$625 million USD each.¹⁴⁵ The Indian *Scorpene* boats, named the *Kalvari* class, are scheduled to be retrofit with AIP technology in the mid-2020s.¹⁴⁶

The Japanese built *Soryu* AIP submarines are large, 2,900 ton ocean-going submarines. The *Soryu* is armed with torpedoes and Harpoon missiles, and boast the Stirling AIP technology. Each *Soryu* boat costs an estimated \$540 million USD.¹⁴⁷

To begin the procurement process, Canada must determine fleet size, build strategy, and whether the future class will be nuclear or non-nuclear. If a non-nuclear submarine is selected, then the requirements should indicate which AIP system the class will utilize. Each system has its own benefits and limitations, and must be carefully considered.

Building submarines in Canada will likely be the costliest option, but it will also provide the most economic and industrial benefits to Canada. Further, this option also provides the strongest domestic apparatus for maintaining the fleet, optimizing the submarines' operational life, and limiting risks to external supply chains and industrial support. This option will also provide Canada with a submarine that best fits its unique operating environment and operational requirements.

¹⁴⁵ Naval Technology “SSK Scorpene-Class Attack Submarine, France.” Naval Technology. Accessed April 16, 2021. <https://www.naval-technology.com/projects/scorpene-class/>.

¹⁴⁶ Ibid.

¹⁴⁷ Peter Haydon, “Canada and Modern Submarines.” *Canadian Naval Review* 12, no. 1 (2016), 36.

CONCLUSION

Canada is a large coastal state with diverse strategic maritime interests in North America and around the globe. As an avid proponent of the rules-based international order, Canada benefits from this order through economic prosperity and peaceful global relations. The RCN contributes to the preservation of rules-based order at sea by operating with like-minded nations to ensure free and unrestricted movement of goods upon the seas. This system, however, is threatened by resurgent great powers, such as Russia and China, and the relative decline of American power. Amidst these geopolitical pressures, submarines are proliferating around the world, into the force structures of more navies today than ever before. Many navies around the world are acquiring submarines because of their capabilities and usefulness. Fortunately, Canada has a long history of procuring and operating submarines.

To support Canadian interests abroad and strengthen the alliances and partnerships that have maintained Canadian security and sovereignty, the RCN requires an effective, professional and modern submarine force. Submarines are suited to a country like Canada, with a relatively small naval forces. Submarines are the ultimate, non-nuclear strategic insurance policy, and offer unrivalled advantages for coastal defence in times of peace and maritime conflict. They are deadly and difficult to detect. Even when adversarial forces are hunting a submarine, it is unwise to think of a submarine as quarry. The submarine is always the hunter. A single weapon fired from a submarine is often enough to sink the most capable warships. Thus, national decision makers take pause when considering whether to deploy a ship into an area where adversarial submarines may be operating.

A submarine is more than just a warfighting platform. Submarines collect valuable intelligence and integrate into a comprehensive system that offers valuable information to other submarine operating nations. This facilitates strategic, operational, and tactical decisions. Further, a submarine offers a valuable training platform for national and international partners to improve ASW skills. A submarine is a multi-purpose machine.

Canada's *Victoria* class is a capable and effective submarine that meets most of Canada's defence capability needs. The *Victoria* class modernization project will upgrade the hulls and the combat capabilities to enable the operation of the gracefully maturing submarines for several more decades. But these submarines require replacement at some date. A procurement process must be initiated soon. When considering a replacement, Canada must weigh which requirements and capabilities are required to fulfill the full spectrum of operations expected of the vessels. These considerations should include the geopolitical situation and Canada's role in supporting its allies within the rules-based international system. Such consideration should include submarine capabilities and other expectations such as propulsion method, under-ice capability, endurance, speed, warfighting, habitability, and communications capacities. Ultimately, a *Victoria* class replacement should allow for a forward-postured submarine flotilla that can control sea lanes of communication and choke points, enforce Canadian sovereignty, and deter conflict. A new class of submarine must be balanced, combat-effective, multi-purpose, survivable, adaptable and agile.

These requirements will determine whether Canada's next submarine flotilla will be nuclear or non-nuclear. If a conventional submarine force is selected, AIP technology

must be carefully reviewed to determine which technology best suits Canada's geographic position and aligns with the platform's requirements. A conventional submarine flotilla using AIP technology provides Canada with a better range of tools to fulfill the fleet's requirements.

Many navies are reinvesting in and recapitalizing current submarine fleets. Canada should investigate whether it is beneficial to partner with an allied navy to collaboratively design and build a replacement boat if no preferable overseas platforms are available for purchase. Notwithstanding the increased cost, incorporating a new submarine fleet into the existing National Shipbuilding Strategy provides Canada with the submarines it needs, meet Canada's unique requirements, and support Canadian industry. Further, building new submarines in Canada would also strengthen national supply chains and increase shipbuilding capacity. These considerations would address national security risks that arise from buying overseas submarines and eliminate reliance on foreign governments to manage maintenance and supply chain requirements. Building Canada's modern submarine fleet domestically would be its strongest option.

Canada maintains an interest in the international rules-based order at sea. A modern, capable, and lethal submarine force is an essential component of maintaining Canadian security, and supporting national and alliance objectives around the world. Canada's experience with submarine operations separates it from many other submarine operating nations. Canadian knowledge has been built up over decades of maintaining and operating submarines. This experience improves Canada's reliability as an ally and partner. Lastly, a submarine is the ultimate guarantor of Canadian sovereignty at sea, and

a force multiplier in a maritime conflict. Canada must not allow this essential capability to erode and must act now to proactively curate the *Victoria* class replacement fleet.

BIBLIOGRAPHY

- Administrator, "Canada's Future Submarines." *Canadian Naval Review*, September 25, 2017. Accessed March 15, 2021. <https://www.navalreview.ca/2017/09/canadas-future-submarines/>.
- Andersson, Jan Joel, "The Race to the Bottom: Submarine Proliferation and International Security," *Naval War College Review*, Vol. 68, No. 1 (2015), 13-29.
- Axe, David, "The Russian Navy's Growing Submarine Fleet Is Ready To Contest NATO Waters." *The National Interest*. The Center for the National Interest, October 1, 2020. <https://nationalinterest.org/blog/reboot/russian-navys-growing-submarine-fleet-ready-contest-nato-waters-169923>.
- Bateman, Aaron, "American Can Protect Its Satellites Without Kinetic Space Weapons" *War On The Rocks*, July 30, 2019. Accessed November 20, 2020. <https://warontherocks.com/2020/07/america-can-protect-its-satellites-without-kinetic-space-weapons/>.
- Byers, Michael and Stewart Webb, "That Sinking Feeling: Canada's Submarine Programme Springs a Leak," (Ottawa: Canadian Centre for Policy Alternatives, 2013).
- Clarke, Lieutenant Commander Jamie A., "China's Naval Modernization in the Mahanian Mirror: Reconsidering Real Force Capacity in the Medium and Longer-Term Perspective", Canadian Forces College Directed Research Project, April 2008.
- Cocking, Janis, Chris Davis and Christopher Norwood, "Australia's Requirement for Submarines" Australian Government, Department of Defence Science and Technology Group, 2016. Accessed 4 March 2021. <https://www.dst.defence.gov.au/publication/australias-requirement-submarines>.
- Collins, Jeffrey F., "In Defence of Canadian Shipbuilding." *Macleans.ca*, March 5, 2021. Accessed March 15, 2021. <https://www.macleans.ca/opinion/in-defence-of-canadian-ship-building/>.
- Collins, Jeffrey F., "Towards a Renewed Canadian Submarine Capability" *Niobe Papers*, No. 4 (July 2019).
- Cooley, Alexander and Daniel H. Nexon, "How Hegemony Ends: The Unraveling of American Power" *Foreign Affairs*, Volume 99, Number 4, (July/August 2020), 143-156.
- Council on Foreign Relations, "What's the Status of North Korea's Nuclear

Program?” Council on Foreign Relations. Accessed November 21, 2020.
<https://www.cfr.org/background/north-koreas-military-capabilities>.

Corbett, Julian Stafford. *Principles of Maritime Strategy*. Mineola (NY): Dover Publications, 2004.

Delaney, Lieutenant Jason M. “Submarine Procurement and the *Victoria*-Class Acquisition from an Historical Perspective: Having Submarines is the Point!” *Canadian Naval Review*, Volume 4, Number 2, (Summer 2008), 22-27.

Department of National Defence, *Canada in a New Maritime World: Leadmark 2050*, (Ottawa, DND Canada, 2015).

Department of National Defence, *Royal Canadian Navy Strategic Plan: 2017-2022*, (Ottawa, DND Canada, 2015).

Department of National Defence, *Strong, Secure, Engaged: Canada's Defence Policy*, (Ottawa, DND Canada, 2017).

Drezner, Dan, Ronald R. Krebs, and Randall Schweller “The End of Grand Strategy” *Foreign Affairs*, Volume 99, Number 3, (May/June 2020), 107-117.

Editor, “Canadian Submarines Conduct Successful Deployments.” *Lookout Newspaper*, December 5, 2018. <https://www.lookoutnewspaper.com/canadian-submarines-conduct-successful-deployments/>. Accessed 27 January 21.

Europa Press. “Navantia Retrasa Hasta Dos Años La Entrega Del Primer Submarino S-80 Por Problemas Técnicos.” Accessed April 4, 2021.
<https://www.europapress.es/economia/noticia-economia-empresas-ampl-navantia-retrasa-dos-anos-entrega-primer-submarino-80-problemas-tecnicos-20130508115530.html>.

Freedman, Lawrence, *The Official History of the Falklands Campaign*, Volume 2: *War and Diplomacy* (London: Routledge, Taylor & Francis Group, 2005).

Galloway, Anthony “Defence Knew Submarines Would Cost Almost \$80b Five Years Ago.” *The Age*, October 13, 2020.
<https://www.theage.com.au/politics/federal/defence-knew-submarines-would-cost-almost-80b-five-years-ago-20201012-p564ea.html>.

Global Affairs Canada “Address by Minister Freeland When Receiving Foreign Policy's Diplomat of the Year Award.” *Canada.ca*. Government of Canada, June 14, 2018.
<https://www.canada.ca/en/global-affairs/news/2018/06/address-by-minister-freeland-when-receiving-foreign-policys-diplomat-of-the-year-award.html>.

Global Firepower, “Defense Spending by Country (2020).” *Global Firepower - World*

Military Strength. Accessed November 11, 2020.
<https://www.globalfirepower.com/defense-spending-budget.asp>.

Global Firepower, “Submarine Fleet Strength by Country (2021).” Global Firepower – World Military Strength. Accessed March 4, 2021.
<https://www.globalfirepower.com/navy-submarines.asp>.

Gorshkov, Sergei G., *The Sea Power and the State*, (Malabar, Florida: Robert E. Krieger Publishing Company Inc., 1979).

Government of Canada, “Canada Announces next Step toward Adding Third Strategic Partner under National Shipbuilding Strategy.” Canada.ca. Public Services and Procurement Canada, December 19, 2019. Accessed March 16, 2021.
<https://www.canada.ca/en/public-services-procurement/news/2019/12/canada-announces-next-step-toward-adding-third-strategic-partner-under-national-shipbuilding-strategy.html>.

Government of Canada, “Canadian Submarine History”, Canada.ca. Government of Canada June 14, 2017. Accessed March 4, 2021.
<https://www.canada.ca/en/navy/services/history/canadian-submarine-history/canadian-submarine-history.html>

Government of Canada, “Canadian Surface Combatants.” Department of National Defence, Royal Canadian Navy, February 18, 2021. Accessed March 1, 2021.
<http://www.navy-marine.forces.gc.ca/en/fleet-units/csc-home.page>.

Government of Canada, “National Shipbuilding Strategy (NSS).” Shipbuilding and Industrial Marine Industry. Innovation, Science and Economic Development Canada, November 3, 2016. Accessed March 16, 2021.
<https://www.ic.gc.ca/eic/site/sim-cnmi.nsf/eng/uv00050.html>.

Griggs, Vice Admiral Ray, “The Role of Submarines in a Maritime Strategy,” Chief of Navy Speeches, 9 April 2014, 7-8. <http://www.navy.gov.au/media-room/publications/chief-navyspeeches-april-2014>. Accessed 25 January 21.

Haydon, Peter, “Canada and Modern Submarines.” *Canadian Naval Review* 12, no. 1 (2016), 35-37.

Haydon, Peter T. “Canada’s Future Submarine Capability” Navy League of Canada, July 2004. Microsoft Word - Submarine Paper _long version_.doc (navyleague.ca).

Kongsberg, “NSM – Naval Strike Missile – Missile Systems.” Kongsberg. Accessed March 2, 2021. <https://www.kongsberg.com/kda/products/defence-a-security/missile-systems/nsm-naval-strike-missile-nsm/>.

Hansen, Ken “A Review of ‘That Sinking Feeling: Canada’s Submarine Program Springs

- a Leak”, *Canadian Naval Review*, Volume 9, Number 2 (2013), 22-26.
- Hellyer, Marcus “Why Does Australia Need 12 Submarines?” Australia Strategic Policy Institute: The Strategist, November 18, 2020.
<https://www.aspistrategist.org.au/why-does-australia-need-12-submarines/>.
- Jolin, Norman “Future Canadian Submarine Capability: Some Considerations”, *Canadian Naval Review*, Volume 11, No. 1, (2015), 16-21.
- Lakeman, J.B., and D.J. Browning, *The Role of Fuel Cells in the Supply of Silent Power for Operations in Littoral Waters*, (Gosport, UK: 2004).
- Macdonald, Scot, "The Falklands Campaign: The British Reconquest and the Argentine Defense." *Marine Corps Gazette* 84, no. 3, (2000), 72-80.
- Mangin, Commander Mike (RCN submariner) in discussion with the author, February 2021.
- Mastro, Oriana Skylar, “The Stealth Superpower: How China Hid Its Global Ambitions”, *Foreign Affairs*, January/February 2019, 31-39.
- Meredith, LCdr Iain, “Canada’s Under-Ice Options: Submarine Air-Independent Propulsion”, Canadian Forces College Service Paper, 2018.
- Milner, Marc. *Canada’s Navy: The First Century* (Toronto: University of Toronto Press, 1999).
- Mitchell, Paul T. “The Deal of the Century: Canada’s Problematic Submarines in Historical Perspective,” Laurier Centre for Military Strategic and Disarmament Studies, 28 June 2013.
- Mitchell, Paul T. “Full of Holes: Byers and Webb on Canada’s Submarine Programme” (Calgary: Canadian Defence & Foreign Affairs Institute, 2013),
- Moltz, James Clay, "Global Submarine Proliferation: Emerging Trends and Problems," Nuclear Threat Initiative Issue Brief, March 2006. Accessed 4 March 2021.
<https://www.nti.org/analysis/articles/global-submarine-proliferation/>.
- Naval News, “Navantia: Development of S-80 Submarine’s AIP System Completed,” accessed April 4, 2021, <https://www.navalnews.com/naval-news/2020/03/navantia-development-of-s80-submarines-aip-system-completed/>.
- Naval Technology, “Projects Archive - Naval Technology.” Naval Technology. Accessed March 2, 2021. <https://www.naval-technology.com/projects/canadian-surface-combatant/>.

- Naval Technology, "SSK Agosta 90B Class Submarine." Naval Technology. Accessed March 16, 2021. <https://www.naval-technology.com/projects/agosta/>.
- Naval Technology, "SSK Scorpene Class Attack Submarine, France." Naval Technology. Accessed April 16, 2021. <https://www.naval-technology.com/projects/scorpene-class/>.
- Nikkei Asia, "Australian Naval Program Sums Up Dilemmas for 'Middle Power' Nations," accessed April 4, 2021. <https://asia.nikkei.com/Politics/Australian-naval-program-sums-up-dilemmas-for-middle-power-nations2>
- Nilson, Thomas, "Norway's New Subs Especially Designed for Covert, Shallow Water Operations." The Independent Barents Observer. Accessed April 4, 2021. <https://thebarentsobserver.com/en/security/2021/03/norways-new-subs-especially-designed-covert-shallow-water-operations>.
- Norwegian Ministry of Defence, *The Defence of Norway: Capability and Readiness* (Oslo: Ministry of Defence, 2020).
- Nuclear Threat Initiative, "Submarine Proliferation Resource Collection." Nuclear Threat Initiative - Ten Years of Building a Safer World, December 16, 2020. <https://www.nti.org/analysis/reports/submarine-proliferation-overview/>.
- Ohff, Hans J. "Nuclear Versus Diesel-electric: The Case for Conventional Submarines for the RAN," Australian Strategic Policy Institute: The Strategist, 11 July 2017. Accessed March 4, 2021. <https://www.aspistrategist.org.au/nuclear-versus-diesel-electric-case-conventional-submarines-ran/>.
- Pincus, Rebecca, "Three-Way Power Dynamics in the Arctic," *Strategic Studies Quarterly* 14, Number 1, (Spring 2020). <https://search-proquest-com.cfc.idm.oclc.org/docview/2393076781?pq-origsite=summon>
- Robinson, Commodore Chris (Commander Canadian Submarine Force, 2017-2019) in discussion with the author, February-April 2021.
- Robinson, Commodore Chris, "RCN Undersea Warfare Future Capability and Challenges" Keynote Address, Deep Blue Forum, October 2020.
- Royal Australian Navy. "Attack Class SSG." Royal Australian Navy. Accessed April 4, 2021. <https://www.navy.gov.au/fleet/ships-boats-craft/future/ssg>.
- Saab, "The Secret to the World's Most Silent Submarine: Stories: Saab" Saab, March 24, 2015. Accessed March 16, 2021. <https://www.saab.com/newsroom/stories/2015/march/the-secret-to-the-worlds-most-silent-submarine>.

- Senate of Canada, *Reinvesting in the Canadian Armed Forces: A Plan for the Future*, (Canada, Standing Senate Committee on National Security and Defence, 2017).
- Shadlow, Nadia “The End of American Illusion: Trump and the World as It Is” *Foreign Affairs*, Volume 99, Number 5, (September/October 2020), 35-45.
- Sharma, Ruchir “The Comeback Nation: U.S. Economic Supremacy Has Repeatedly Proved Declinists Wrong” *Foreign Affairs*, Volume 99, Number 3, (May/June 2020), 70-81.
- Sebastian Sprenger, “German, Norwegian Officials Huddle over Joint Submarine Program.” *Defense News*, Accessed April 4, 2021.
<https://www.defensenews.com/global/europe/2019/04/30/german-norwegian-officials-huddle-over-joint-submarine-program/>.
- Sukhdeo, Marcello, “The Capabilities and Challenges of Canada’s Future Fleet: Interview with Commodore Christopher Robinson, Director General Naval Force Development, Royal Canadian Navy”, *Vanguard Canada*, (October/November 2020), 18-22.
- Till, Geoffrey. *Seapower a Guide for the Twenty-First Century*. (Abingdon, Oxon: Routledge, 2018).
- Webster, Captain (N) Phil “Arctic Sovereignty, Submarine Operations and Water Space Management” *Canadian Naval Review*, Volume 3, Number 3, (2007), 14-16.
- Wezeman, Pieter D., Aude Fleurant, Alexandra Kuimova, Nan Tian, and Siemon T. Wezeman. “Trends in International Arms Transfers, 2018.” Stockholm International Peace Research Institute. Accessed March 4, 2021.
<https://www.sipri.org/publications/2019/sipri-fact-sheets/trends-international-arms-transfers-2018>.
- Whitman, Edward C., “Air Independent Propulsion – AIP Technology Creates a New Undersea Threat” *Undersea Warfare*, Issue 13, (2004), 1-6.