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# The Future of Submarines in Canada

Lieutenant-Commander Ashley N. Hunt

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# THE FUTURE OF SUBMARINES IN CANADA

By Lieutenant Commander A.N. HUNT
Par le capitaine de corvette A.N. HUNT



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A2/AD – Anti-Access and Area Denial

ADM(Mat) – Assistant Deputy Minister of Materiel

ASW – Anti-Submarine Warfare

AUV – Autonomous Underwater Vehicle

CAF – Canadian Armed Forces

CASAP – Canadian Submarine Acquisition Program

CCPA – Canadian Centre for Policy Alternatives

CNS – Chief of Naval Staff

CPSP – Canadian Patrol Submarine Project

CSA – Chief Submarine Acquisition

CWP – Canadianization Work Period

EDWP – Extended Docking Work Period

FMF – Fleet Maintenance Facility

HMCS – Her Majesty's Canadian Ship/Submarine

ISR – Intelligence, Surveillance, Reconnaissance

MND – Minister of National Defence

MOTS – Military-Off-The-Shelf

NATO – North Atlantic Treaty Organization

NSOS – Nuclear Submarine Option Study

O-Boat – Oberon Class Submarine

PM – Prime Minister

RAN – Royal Australian Navy

RCN – Royal Canadian Navy

RN – Royal Navy

ROV – Remotely Operated Vehicle

SSE – Strong, Secure Engaged, a Defence Policy for Canada (2017)

SUBRONONE – First Canadian Submarine Squadron

SSK – Diesel-Electric Attack Submarine

SSN – Nuclear Attack Submarine

TKMS – ThyssenKrupp Marine Systems

UK – United Kingdom

US – United States

USN – United States Navy

UUV – Unmanned Underwater Vehicle

WWI – World War I

WWII – World War II

**ABSTRACT**

Canada needs a submarine service beyond the tenure of the Victoria class. First acquired in haste at the outset of WW1, Canadian submarines received fitful support from the government and the navy, both of which have invested in the capability. Canada's geography and strong continental partnership with the US justified the effort and investment, because the submarine is a platform in the CAF inventory whose influence reaches vastly beyond its immediate operating environment. Submarines possess stealth and endurance that give a single submarine influence over the majority of Canada's territorial and continental maritime domain. The submarine is taking on greater importance in the contemporary strategic and operating environments. The pace of technological evolution in the areas of weapons and sensors will increasingly defeat the traditional surface warship, while the dynamics of global power competition continue to create increasingly contested maritime regions. Submarines will therefore become the backbone of any ranking navy, conducting the necessary surveillance, deterrence, and offensive action that is necessary to successfully operate in critical maritime regions either at home or abroad. As a resource constrained armed forces, Canada relies on its allies for the defence of the homeland. To reinforce those important alliance relationships, Canada must continue to offer submarine-based contributions in ASW training and maritime warfare.

The Victoria class replacement should be based on a minimally modified MOTS design with proven technology, and meticulously refined roles in which it will be employed. The class sustainment plan must be well-considered alongside procurement to ensure Canada retains its submarine capability, but also ensure the submarines can reliably achieve operational availability goals. It is indeed exciting times, as Canada starts to look at modernizing this critical capability, and rejuvenating the RCN with modern and reliable submarine platforms.

## INTRODUCTION

A modern submarine fitted with cutting-edge technology and a highly competent crew is a formidable foe capable of influencing the maritime domain in ways that surface warships cannot. These assets can be tailored to a wide variety of operational requirements including global deployment, littoral operation, under-ice capabilities, sovereignty, force projection against adversaries, sea denial, surveillance and intelligence-gathering. Submarines, with the right configuration and flotilla size, provide multiple capabilities to the Canadian Armed Forces (CAF) and play a critical role in supporting Canada's defence policy, outlined in *Strong, Secure and Engaged* (SSE).[1] Although Canadian submarines have over a hundred years of history, inconsistency and wavering support from politicians, the Canadian public, and even within the Royal Canadian Navy (RCN) and CAF has predominated.

The Victoria class submarines have had a difficult tenure in the RCN, with media coverage dominated by fires, accidents, unforeseen repair requirements, and long periods of maintenance with seemingly limited operational availability. The Victoria class is currently undergoing life extension to bring the end of service lives from the early 2020s to the mid 2030s, so the class has roughly a decade of service life left. To prevent the possibility of any gap between the Victoria class and its successor, Canada should plan to commission its future submarines starting in the mid-2030s or risk spending significant resources in a desperate effort to further life-extend the Victoria class. These resources would amount to a submarine limited in operational capability due to significant safety concerns related to system and structural integrity after more than four decades of service. Either way, Canada should soon begin considering a

[1] Canada, *Strong Secure Engaged* (Canada: Department of National Defence, 2017b). 14.

replacement submarine. If history is any judge, submarine procurement projects in Canada inevitably devolve to debates about whether Canada needs submarines. However, it is not a question of whether Canada needs submarines, since Canada urgently needs them in today's operating environment. Submarines are an ideal platform to meet Canada's defence requirements of continental defence and protection against external threat to the homeland, while also contributing to Canada's key alliances with the United States (US) and the North Atlantic Treaty Organization (NATO). The future of maritime defence is in the underwater domain, and Canada needs to stay engaged in a credible manner.

What should Canada's next submarine look like? Submarines are a preferred capability to meet Canada's national defence and security goals as a reliable continental partner to the US for many practical reasons. However, Canada must scrutinize the operational role of its future submarine flotilla, the capabilities these assets require, and seek options from submarine designs currently on the market. Procurement of new submarines, alone, will not be enough to ensure the success of Canada's submarine program. Procurement is merely the first step in having a successful submarine capability. The RCN needs to sell submarines to the public, well before replacement takes place. That means having a visible domestic presence by means of port visits, fisheries patrols, and media days. Submariners need to show that submarines *are* integral to the RCN, and that they will be the high end warfighting asset in the decades to come, that is versatile and endearing. The doctrinal, material, and personnel needs are equally important. The RCN must therefore ensure that equipment lifecycle is supportable, while maximizing operational availability. Canada's submariners have to be recruited, trained and supported in a way that fosters a proud submarine community.

Canada urgently needs a submarine service. Its vast coastlines and dependency on alliances demands it. Three things must occur for Canada to achieve this. First, Canada must improve upon the challenges that the submarine service has experienced over the last one hundred years to procure and sustain the right assets for Canada's needs. Secondly, it must clearly define the purpose and roles for its next submarine flotilla, and employ the assets reliably in those roles. Lastly, Canada must select, procure, and sustain the right submarine to replace the Victoria class. Success in these three areas ensures that Canada meets its objectives in the maritime defence domain now, and in the decades to come.

Canada's participation in the modern international submarine community is a capability that has been built up at considerable cost and effort, and should not be taken for granted. The history of submarines in Canada is one of wavering public and political support, opportunistic acquisitions, and modest ambitions. Canada stumbled into submarine ownership in 1914 and has invested tremendous effort to procure and maintain these assets ever since, at times resorting to renting the capability from allies. Procurement of Oberon class submarines in the 1960s represents an important turning point, restoring Canada's organic submarine capability, continued with the Victoria class submarines since the early 2000s. If Canada is to retain this important capability, it should soon begin the process of identifying the Victoria class replacement and the important roles and needs that submarines fulfill on the domestic and continental scenes. Whichever submarine Canada chooses should be procured and maintained in ways that overcome the difficulties of the past. A chronological historical outline of submarine development in Canada, from the hastily procured and comparatively simplistic boats of World War I (WWI), to the sophisticated boats of today, shows the turbulent yet persevering nature of the Canadian

submarine service. It highlights the difficulties Canada has had with gaining public support, seeking realistic procurement options, and maintaining an operational submarine flotilla.

Submarines are remarkably effective instruments for sea denial and exerting sovereignty off the coasts of Canada. They occupy an important place in Canada's fleet, today and into the future.[2] Canada has always needed submarines for the protection of its long coasts and vast maritime estate, on a continental basis with American partners. Since 1949, Canada's anti-submarine warfare (ASW) capability has been considered a critical component of Canada's contribution to its alliance with NATO, and an organic Canadian submarine capability is vital to Canada's ASW proficiency. Geography and alliances have been an enduring justification for Canada's submarine requirements. These enduring facts make Canadian submarines a necessity for the nation's overall defence strategy. The evolution of the maritime domain, along with changing dynamics of global politics has reinforced the submarine as a critical component of the RCN. As technology increases the capabilities of potential adversaries to find and engage surface warships, the future of maritime warfare is increasingly being driven underwater. Many countries with small or medium sized navies are recognizing this and developing submarine capabilities of their own, with a variety of cheaper submarine options for smaller navies. Globalization and consumerism have increased the density of maritime-dependant trade. Many countries, including Canada, are dependant on the security of maritime commerce. With technological advances and increased maritime traffic density, there is simply no where for warships to hide in maritime conflict, while submarines still provide stealth, endurance, and lethality. Submarines offer a modern navy the tactical advantage of the element of surprise, a covert advantage in a politically

[2] Canada, *Leadmark 2050 - Canada in a New Maritime World* (Canada: Department of National Defence, 2016b). 39.

volatile world, and a lethality which, in and of itself, creates a deterrent against even the most capable adversary.

Canada needs submarines for coastal and continental defence and as a critical contribution to its alliances. Defining the roles that Canada's future submarine flotilla will fill is critical, and Canada must find the balance between what it needs and what it can support, and not become distracted by mere wants. Submarines have never been popular in Canada, so this investment will be difficult to sell to the Canadian public. This project really is a public relations battle, and deliberate efforts on the part of the RCN will be required to demonstrate to the Canadian public that submarines are critical to the RCN, and that Canada can not only support and operate them, but that the RCN simply cannot do without. The justification for submarines needs to be made now, to lay the groundwork for future procurement. That means showing Canadians exactly what submarines do and how indispensable they are to Canada's national defence priorities. Submarines are at forefront of maritime defence and security. They are capable of observing the domain while remaining undetected, deterring potential adversaries, or engaging enemies with swift and precise lethality. Submarines are extremely effective in applying force at sea, and are an essential part of the RCN's ability to meet Canada's maritime defence requirements.

To determine the most suitable replacement options for the Victoria class, the RCN must translate the submarine's roles into tangible capabilities, and should seek options based on proven submarine designs. Replacement options must be examined against suitability to fill those roles and Canada's capability to sustain submarines in terms of maintenance and personnel. There are options currently available from Canada's international partners that could meet the RCN's needs. Four such options include the German Type 214, French Scorpene class, Swedish Type A-26, and Japanese Soryu class. Canada's future submarines must serve a well-defined purpose, be

materially supportable, and be supported by a submarine enterprise that can ensure operational availability. The options are bound by the overriding assumptions that Canada's next submarine will not be nuclear-powered, and that Canada will seek a military-off-the-shelf (MOTS) design requiring minimal Canadian modifications to a foreign design and built in Canada or overseas. These assumptions would require further analysis by the RCN during the Victoria class replacement project.

The analysis herein accepts the idea that Canada needs submarines. Removal of submarines from the RCN's inventory would be ill-advised and adversely denigrate Canada's ability to patrol and protect its coasts and the continent of North America. In today's operating environment, the RCN requires a submarine capability. Submarines have an important role in Canada's future maritime defence strategy, and through procurement of the right assets with optimized operational availability, and fostering a proud community of submariners, Canada *shall* remain relevant in submarine operations on the international stage.

As a submariner, the author believes that Canada needs submarines and that submarine ownership and operation is worth the expense.[3] The author acknowledges this bias. The analysis herein is constrained by some key assumptions. First, that Canada will not, at least in the lifetime of the post-Victoria Class Submarine fleet, entertain the notion of operating nuclear submarines (SSNs). Secondly, that Canada is unlikely to get into the business of building its own submarines by virtue of the small numbers and economics involved. Canadian industries could certainly play

[3] The author of this Research Paper is a serving Submariner in the RCN. She has been working with, sailing in, and supporting the Victoria Class since 2010 and therefore has inherent knowledge of the Victoria Class Submarines, the Canadian Submarine Enterprise, and the capabilities of submarine operations. She has endeavoured to rely on doctrine and open-source information; however, where appropriate, she has relied upon her knowledge and experience to provide supporting evidence.

a role in construction of the future submarines, doing so would be highly palatable in fact, as it brings employment opportunities to Canada while leveraging the expertise of submarine design and construction from the nation where the design originated. But Canada will not be getting wholeheartedly into the submarine construction or export field. Lastly, Canada intends its submarine service to remain mostly, if not wholly, a volunteer service, and it is therefore critical that Canada be able to attract and retain exceptional sailors that have earned the right to call themselves submariners. Crewing requirements of a submarine are approximately a third that of a frigate, and have more capability and lethality. They are the economical and cheaper choice of any navy.

**The Submarine Debate**

Media, politicians, and military personnel have debated Canada's need for submarines for over 100 years. The debate reignites with any announcement related to submarine procurement, as was the case with Canada's last two submarine procurement efforts: the Oberon class in the 1960s and the Victoria class in the 1990s. The procurement strategy used for the Oberon and Victoria classes were quite different. The Oberons were built for Canada, while the Victoria class were second-hand British boats deemed surplus in Great Britain by the decision to focus on an all-nuclear submarine flotilla. The response of Canadians and government officials, however, were the same; submarines are a large investment, so does the RCN *really* need them? In reality, the capabilities inherent to a submarine in terms of deterrence and lethality make the submarine a much more cost-effective alternative to large surface ships. Hull-for-hull, a modern diesel electric submarine is actually less expensive than a large modern surface ship.[4] Canada now finds itself,

[4] Modern SSK's are approximated at $500 million USD per hull, while the Canadian Surface Combatant contract is currently worth approximately $60 Billion for 15 ships.

once again, with a submarine fleet that is nearing end-of-life. The design-life of the boats expires in the early 2020s, while life extension efforts will extend their service until the mid-2030s; further life-extension, if so required, would come at great cost and an acceptance of limited operational capability.[5] It is time for Canada to consider what comes next, and why the RCN needs submarines. In preparation for the next round of this inevitable debate, it is worth exploring the historical discussions surrounding Canada's last two submarine procurements, as well as the controversy sparked throughout the tenure of the Victoria Class since the early 2000s. This literature review aims to highlight the reasons that Canadians, media, politicians and members of the CAF have historically argued for, or against, Canada's need for submarines. Chapter two further explores why Canada needs submarines today and into the future, and seeks to address some relevant themes found in the literature.

Canada has made serious consideration regarding the procurement of nuclear-powered submarines twice, once in the 1950s and again in the 1980s. On both occasions, nuclear-powered submarines were found to be too costly, the procurement and sustainment too complex, and the offensive nature too un-Canadian.

In the mid-1950s, the RCN's submarine service was equipped with three rented British submarines operating out of Halifax, and one rented American submarine operating out of Esquimalt. The RCN took on an ASW expertise role in the NATO alliance. When Great Britain announced that it could no longer guarantee three submarines for use in Canada, the government was forced to seek procurement options. Nuclear-powered submarines were a brand new concept at that time, only operated by the Americans with *USS Nautilis* being the first of its kind launched

[5] Canada, *Strong Secure Engaged* (Canada: Department of National Defence, 2017b). 65. And Canada, *Leadmark 2050 - Canada in a New Maritime World* (Canada: Department of National Defence, 2016b). 42.

in 1955.[6] The Americans showcased one of their nuclear submarines for RCN officials in 1957, and in May 1958, the Chief of Naval Staff, Vice-Admiral Harry DeWolf, announced that Canada would build its own nuclear submarines.[7] The media latched on to three major selling features of the nuclear submarine option: building them in Canada would bring much-needed work to Canadian shipyards; that the RCN needed its own, not rented, submarines for maintaining its ASW role in the NATO alliance; and nuclear submarines would also be capable of the *real thing*, hunting and killing enemy submarines if needed, even under the Arctic ice where it was suspected that Russian submarines were operating.[8] Merely six months after this announcement, media outlets were forecasting, accurately, that the RCNs procurement plans were ambitious. On 11 December 1958, the *Ottawa Citizen* stated that "the navy's long range requirements are of such proportions that they stagger the imagination, and could cripple the nation's economy if any attempt should be made to meet them in full."[9] By March 1959, the Minister of National Defence (MND), after receiving an interim report from the Nuclear Submarine Survey Team, expressed concern over the vast cost of the nuclear submarine program.[10] As the cost of the program put nuclear submarines out of reach, the MND and CNS changed course, reverting to the idea that Canada would instead build diesel-electric submarines, only to discover that the Canadian public and government officials had soured on the idea of *any* Canadian submarines. Internal memorandums in the CNS office stated that "there is an impression in this country that

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[6] "Nuclear Powered Ships."https://www.world-nuclear.org/information-library/non-power-nuclear-applications/transport/nuclear-powered-ships.aspx#:~:text=The%20first%20nuclear%2Dpowered%20submarine,had%20come%20into%20its%20own. (accessed 2 March, 2021).

[7] Julie H. Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 270-271.

[8] Courtney Tower, "Canada-made, A-Powered Submarines to Form RCN's Major Fighting Force," *The Daily Colonist* May 10, 1958. https://archive.org/details/dailycolonist0558uvic_7/mode/1up?view=theater.

[9] Charles Lynch, "The Job: Fight Subs, Role of the Navy Only Sure Thing as Experts Wrestle Estimates," *The Ottawa Citizen* December 11, 1958. https://news.google.com/newspapers?id=TsExAAAAIBAJ&sjid=IeMFAAAAIBAJ&pg=7117%2C2538263. 25.

[10] "Pearkes Shudders to Think of Cost of Nuclear Subs." *Ottawa Journal* 31 March, 1959.

submarines are almost in the same classification as poison gas."[11] The RCN had done a good job selling the nuclear submarines as an offensive tool, and were now suffering the consequences of that. In 1960, Canadians could easily recall the ways that the enemy had used submarines in WWII and the Battle of the Atlantic. This offensive role was thought to be in contrast to Canadian morals.[12] The cost of the nuclear program was too high, and the perceived aggressive nature of the submarine was too un-Canadian. With that, the nuclear-powered submarine program was cancelled.

The nuclear-powered submarine option was revived in the 1980s when Canada sought a replacement for the Oberon Class. The strategy was to purchase a proven design from one of Canada's allies, and have the submarines built in Canada.[13] The 1987 Defence Policy highlighted Canada's need for a three-ocean capable navy, depicting the Arctic as an important strategic environment where the threat of Soviet nuclear submarines required Canada's attention.[14] Much to the surprise of Canadians, the White Paper announced that Canada would acquire a fleet of 10-12 nuclear submarines, justified by the notion that it was the only asset that could project sovereignty in the Canadian Arctic, and detect and engage Soviet submarines already thought to be staged there.[15] Some politicians felt that this would bring Canada into a "dangerous cat and mouse game of superpower strategy", and feared that operating nuclear submarines could draw Canada into any future conflicts between the US and Russia.[16]

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[11] "Memo from NComp to VCNS."79/246, Folder 175, NPCC Project File M11, Department of History and Heritage, 1960).

[12] Jason Delaney, "The One Class of Vessel that is Impossible to Build in Australia, Canada," *The Northern Mariner* 24, no. 3 (2014), 260-272. https://www.cnrs-scrn.org/northern_mariner/vol24/tnm_24_34_260-272.pdf. 264.

[13] Jason Delaney, "The One Class of Vessel that is Impossible to Build in Australia, Canada," *The Northern Mariner* 24, no. 3 (2014), 260-272. https://www.cnrs-scrn.org/northern_mariner/vol24/tnm_24_34_260-272.pdf. 266.

[14] Canada, *Challenge and Committment - A Defence Policy for Canada* (Ottawa: Government of Canada,[1987]). 6, 11, 14, 24, 49-51.

[15] Canada, *Challenge and Committment - A Defence Policy for Canada* (Ottawa: Government of Canada,[1987]). 52-53.

[16] Hilary MacKenzie and Marc Clark, "A Defence Plan for Canada," *Maclean's (Toronto),* Jun 15, 1987, .

Many Americans were skeptical of this announcement. Wondering how Canada would acquire the technology and training required to build and operate the submarines, they called into question Canada's intentions. Speculation was that Canada wanted to close off passage through the Arctic to American submarines in an attempt to legitimize Canada's claims that the Northwest Passage constituted Canadian waters.[17] Despite skepticism in some circles, the 1987 nuclear submarine procurement announcement seemed to be progressing, and the 1988 Defence Policy Update reiterated the nuclear submarine program as the only solution to Arctic operations, while acknowledging that the program had received criticism.[18] The program was estimated to cost $8 billion, the largest military procurement program ever, which grew to $10 billion, but even then government officials were skeptical of the costing figures.[19] The final cabinet meeting to approve the procurement was scheduled for 11 May 1988, but was abruptly cancelled after the Secretary of State for External Affairs, Joe Clarke, acting for the Prime Minister, read a briefing note that had been submitted by the Treasury Board on the matter. The meeting was never rescheduled, and nuclear submarine procurement quietly faded out.[20] It is thought that this briefing note highlighted costing discrepancies in the program. Similar to the 1959 nuclear submarine saga, cost overruns overshadowed this project, but concerns from the US, which saw the program as a challenge to its own Arctic underwater operations, were also at work.

The argument in support of nuclear-powered submarines in Canada is an enduring one. Much of Canada's northern border remains inaccessible to RCN assets, and climate change continues to make those waters more accessible for nations with ice-capable vessels. The nuclear

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[17] Richard Halloran, "U.S. Suspicious of Canada's Plan for Nuclear Subs," *The New York Times*4 May, 1987. https://www.nytimes.com/1987/05/04/world/us-suspicious-of-canada-s-plan-for-nuclear-subs.html. 14.

[18] Canada, *Defence Update 1988-1989* (Ottawa: Government of Canada,[1989]). 10.

[19] Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 355-356.

[20] Delaney, "The One Class of Vessel that is Impossible to Build in Australia, Canada," *The Northern Mariner* 24, no. 3 (2014), 260-272. https://www.cnrs-scrn.org/northern_mariner/vol24/tnm_24_34_260-272.pdf. 269.

debate is likely to be revisited in the future, but the RCN would have to overcome the common pitfalls of the 1960s and 1980s, where costing was unpalatable, the program complexities seemingly outside of the RCN's capabilities, and the political sensitivities surrounding nuclear submarines too great.

Procurement efforts for Canada's last two classes of diesel-electric submarines also attracted debate. Following the failed nuclear submarine procurement efforts of the 1950s, the RCN turned toward the rationale that conventional submarines in Canada would be used to act as targets in ASW training at home and abroad, and were less expensive than the nuclear option. In 1960, the RCN also abandoned the notion of building submarines in Canada, and turned its focus to purchasing a small number of Oberon class conventional submarines from the United Kingdom (UK). So in the 1950s and 1960s, after over a year of study, nuclear submarines were deemed too expensive, submarines in general were deemed too offensive, and the navy reverted to advertising the submarine procurement program as a means to hold up its commitment as an ASW expert in the NATO alliance. The Oberons were used primarily in this training role in their first two decades, but underwent an operational upgrade in the 1980s that enabled the submarines to take on operational missions, bridging Canadian submarines out of their traditional ASW training role.

When time came to replace the Oberons, tandem to the nuclear submarine procurement efforts was a project to build diesel-electric submarines in Canada. But it was cancelled when the nuclear submarine procurement option gained momentum after the release of the 1987 White Paper. By the early 1990s, the conventional and nuclear projects had been cancelled, and Canada had very little time to find a solution before the Oberons would be de-commissioned. When the Prime Minister announced purchase of four British Upholder submarines, it was touted as a good deal: an "eight year interest-free, lease-to-buy arrangement," costing $750 million for four

submarines that cost Great Britain $2.28 billion to build in the 1980s.[21] The Upholder submarines, renamed the Victoria class in Canada, have been on trial in the media ever since, and the value of this purchase is still questioned by many today.[22] The tragic fire aboard *HMCS CHICOUTIMI* in October 2004, which killed one Canadian submariner and injured others, instilled the belief that the submarines were not well-built. Government opposition leaders accused the government of endangering the lives of military personnel for the sake of a good deal, and media outlets openly asked why good money should be spent on "these pesky underwater contraptions" to make them safe and operational.[23]

The Victoria class have suffered a myriad of negative coverage since the early 2000s, as a result of long periods of maintenance, gaps in operational availability, unforeseen repair requirements, accidents, and difficulties in crewing the four submarines.[24] In 2013, the Canadian Centre for Policy Alternatives (CCPA) released a report that examined the reasons typically used in support of submarines in Canada, and attempted to systematically debunk each of them. The six topics included: surveillance and law enforcement; training with the US Navy; Arctic operations; the Northwest Passage; conflict in the Pacific; and maintaining submarine expertise.[25] The report posits that although submarines have stealth and endurance for coastal surveillance in prosecution of fisheries violators, smugglers or polluters, that the job would be done better by unmanned aircraft that can travel greater distances in shorter times, which is important for a

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[21] CBC News, "Canada Buys British Submarines," *CBC News*13 November, 1998. https://www.cbc.ca/news/canada/canada-buys-british-submarines-1.164542.

[22] Michael Byers and Stewart Webb, *That Sinking Feeling: Canada's Submarine Program Springs a Leak* (Ottawa: Canadian Centre for Policy Alternatives, 2013). https://deslibris.ca/ID/238134. 10-19.

[23] Peter Newman, "The Submarine Fiasco," *Maclean'S,* October 25, 2004, .

[24] For example: Steve Bandera, "W5 Investigates Canada's Floundering Submarine Fleet," *CTV News*12 November, 2011. https://www.ctvnews.ca/w5-investigates-canada-s-floundering-submarine-fleet-1.724641. and David Pugliese, "Submarine Repair to Cost $18 Million," https://ottawacitizen.com/news/national/submarine-repairs-to-cost-18-million (accessed 3 March, 2021).

[25] Byers and Webb, *That Sinking Feeling: Canada's Submarine Program Springs a Leak* (Ottawa: Canadian Centre for Policy Alternatives, 2013). https://deslibris.ca/ID/238134. 20-28.

country like Canada with vast oceanfront to patrol. *Leadmark 2050* highlights strategic deterrent effect that submarines had on the Turbot War in 1995, but stops short of selling the Victoria class, or any future submarine for this purpose.[26] ASW training, with the US and other allies, is mentioned in all Canadian defence policies and white papers since 1964. The CCPA simply suggests that maintaining a submarine enterprise for training Canada's allies is a strange use of defence funds, and that the allies can certainly find other submarines to train with.[27] Contrasted against 50 years of defence policies, the value of this service in support of Canada's most valuable alliances, namely the bilateral alliance with the US and the multilateral alliance with NATO, cannot be over-stated. Canada relies on allies for security at home, and it must contribute to alliances in a meaningful way to ensure reciprocal advantage**.** The importance of Canadian sovereignty in the Arctic and in the Northwest Passage have historically been cited as a driving factor for Canada's need for nuclear submarines. However, Canada is yet to own submarines capable of operating under ice. While the report acknowledges the growing justifications in the prediction of conflict in the Pacific, China's economic relationships are likely to outweigh reasons for conflict, and as such Canada should not need to prepare a force capable of maritime combat in the Pacific. Finally, the report rebukes the idea that submarine expertise would be hard to rebuild if allowed to lapse by comparing it with Canada's decision to cease operating cavalry or aircraft carriers. This final point may have been intended as somewhat facetious, but the importance of this point is often understated. Any gap between the current and future submarine flotillas would significantly degrade the RCN's submarine capabilities, and require significant time and effort to

[26] Canada, *Leadmark 2050 - Canada in a New Maritime World* (Canada: Department of National Defence, 2016b). 15.

[27] Byers and Webb, *That Sinking Feeling: Canada's Submarine Program Springs a Leak* (Ottawa: Canadian Centre for Policy Alternatives, 2013). https://deslibris.ca/ID/238134. 21.

rebuild the submarine enterprise, regenerate qualified submariners, and rebuild the corporate knowledge required to operate and maintain these assets.

So what does this mean for today, and for the next submarine replacement project? If Canada intends to study the feasibility of a nuclear submarine program, it must ensure that cost estimates are thorough and well-articulated. It must also consider the impact that Canada's nuclear submarine program would have on alliance relationships, and how a rebalance of the defence budget to support nuclear submarines would affect the rest of the CAF. If Canada intends to procure diesel-electric submarines, as is most likely, then it must clearly establish the role that the submarines are intended for, select equipment that supports that role, and ensure that the submarines are managed such that they are operationally available to fulfill that role. When Canada announces a submarine procurement program, it must be prepared to defend the program with clearly articulated roles and capability requirements, and must show Canadians that Canada can do better than it has with the Victoria class. Most importantly, Canada needs to sell submarines to the public and polity as a key component of the RCN and CAF.

## CHAPTER ONE – FROM WHENCE WE CAME

Canada has over a century of history with submarines. That story is an interesting one, with much drama and intrigue. Grudging acceptance, failed ambitious procurement strategies, and opportunistic acquisition factor into the narrative. Despite this turmoil, Canada has managed to maintain its presence in the international submarine community, with significant effort and investment, and has operated a variety of submarines that have been effective in their roles. Therefore, Canada needs to change the narrative on submarines. Past successes should be celebrated, and failures not dwelled upon or repeated, as submarines are central to Canada's *Jeune École* fleet.

### 1914-1918: British Columbia's Submarine Fleet

The Canadian submarine service arose from a decision by British Columbia Premier, Sir Richard McBride, to purchase two submarines from a private shipyard with provincial funds under the cover of darkness at the outbreak of WWI. Procurement of Canada's first submarines was unusual to say the least, and sets the tone for the unusual story of the Canadian submarine service.

In the days preceding declaration of war between Great Britain and Germany, Great Britain had withdrawn its naval forces from the Pacific, leaving allied protection of the Pacific in the hands of the Japanese.[28] Canada's naval dockyard in Esquimalt had only one warship in harbour, *HMCS RAINBOW*, a 23-year old protected cruiser only 6 years from being

[28] Starr J. Sinton, "British Columbia's Submarine Fleet - CC-1 and CC-2," https://navalandmilitarymuseum.org/archives/articles/defending-the-coast/cc1-and-cc2/ (accessed 1 February, 2021).

decommissioned.[29] *HMCS RAINBOW* had seen better days, and the old lady was in no shape for a fight. This vulnerability was known by Premier McBride, and the concern of his constituents was shared at the highest levels.

The Seattle Construction and Drydock Company had just built two submarines for the Chilean Navy, for which it was having trouble receiving payment. During a business meeting in Victoria, the company's President, Mr. Paterson, mentioned these submarines, and discussions ensued regarding the possibility of selling them to Canada.[30] This message was passed to Premier McBride, who immediately made requests to Ottawa to proceed with the purchase. Fearing that a decision could not be made expediently enough, Premier McBride took matters into his own hands with a bold plan. He secured $1.1 million in provincial funds required to make full payment, and set up an overnight meeting where the submarine exchange would take place.[31] Late on 4 August 1914, Mr. Paterson set sail from Seattle with the two submarines to rendezvous with British Columbia representatives off the coast of Trial Island. The two submarines officially became the property of British Columbia in the early hours of 5 August 1914, when a cheque for the agreed amount was handed over.[32] Seemingly overnight, BC had established an effective coastal defence, because the two submarines were very effective sea denial weapons, and posed a large enough threat to deter German naval forces, although the submarines still lacked trained crews and torpedoes. This opportunistic acquisition set an appropriate tone for future submarine procurements in Canada.

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[29] Clare Sharp, "Hmcs Rainbow," https://navalandmilitarymuseum.org/archives/articles/ship-histories/hmcs-rainbow/ (accessed 1 February, 2021).

[30] J. David Perkins, *The Canadian Submarine Service in Review* (St. Catharines, Ontario: Vanwell Publishing Limited, 2000). 71.

[31] Sinton, "British Columbia's Submarine Fleet - CC-1 and CC-2," https://navalandmilitarymuseum.org/archives/articles/defending-the-coast/cc1-and-cc2/ (accessed 1 February, 2021).

[32] Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 23.

On 7 August 1914, the Government of Canada took ownership of the two submarines, and welcomed them into the RCN. The province of British Columbia was reimbursed in full, an amount which doubled the entire RCN budget from the preceding year.[33] The Government also ordered an inquiry into this purchase, and in that report, Commissioner the Honourable Sir Charles Davidson applauded the actions of Premier McBride, stating: "[w]hat Sir Richard McBride did in those days of great anxiety, even distress, and what he accomplished deserves the commendation of his fellow countrymen. For his motives were those of patriotism: and his conduct that of an honourable man."[34]

Canada's first submarines, *CC-1* and *CC-2,* were small, diesel-electric coastal defence submarines with a submerged displacement of approximately 400 tonnes and a crew of 20.[35] They conducted coastal defence activities on the Pacific coast until 1917 when they were relocated to Halifax, becoming the first Canadian naval vessels to transit the Panama Canal. They had limited operational value after that long journey, and were paid off in 1920.[36]

**1915-1922: H-Class Submarines**

In 1915, after a year long struggle to develop an understanding of submarines and to adequately train the submariners required to crew *CC-1* and *CC-2*, Canada, unbeknownst to Prime Minister Robert Borden, began building submarines at Vickers shipyard in Montreal. Vickers had been given a contract from the Americans to build ten H-Class submarines for Great Britain. The

[33] Sinton, "British Columbia's Submarine Fleet - CC-1 and CC-2," https://navalandmilitarymuseum.org/archives/articles/defending-the-coast/cc1-and-cc2/ (accessed 1 February, 2021).

[34] Charles Davidson, *Report of the Commissioner Concerning the Purchase of Submarines* (Ottawa: Government of Canada,[1917]). 23.

[35] Canada, "Canadian Submarine History Facts and Figures," https://www.canada.ca/en/navy/services/history/canadian-submarine-history/canadian-submarine-history-facts-figures.html#1914 (accessed 1 February, 2021).

[36] Sinton, "British Columbia's Submarine Fleet - CC-1 and CC-2," https://navalandmilitarymuseum.org/archives/articles/defending-the-coast/cc1-and-cc2/ (accessed 1 February, 2021).

Americans had been asked by the British Admiralty to build twenty such submarines. However, due to the American stance of neutrality before formally entering the war there was a high level of bureaucracy that hindered American production, so half of this contract was given to Vickers. Although Borden was unhappy to have been left out of decision making for this construction, he saw the benefits of job creation in a depressed Montreal economy, and potential opportunity for Canada to purchase a couple H-Class boats to expand its own submarine service.[37] Borden tried to arrange a deal that would see the last two of the ten H-Class boats given to the RCN, with the understanding that Vickers would then build a further two to meet the British requirements. This deal was denied by the British Admiralty, as they deemed the Canadian Atlantic to be at low risk of attack. In the end, Vickers built the ten H-Class submarines for the Royal Navy (RN) at record speed, completing all ten in approximately six months, well ahead of what had been considered an ambitious timeline. The Canadian-built H-Class submarines were sturdy. They were the first submarines to cross the Atlantic under their own power, a transit that took 13 days.[38] Vickers never built H-Class submarines for the RCN, but they did build eight for Italy and six for Russia.[39]

Many Canadian submariners volunteered for service in British submarines, many of them sailing in the Canadian-built H-Class boats in European waters. During WWI, the RCN gained considerable experience with these boats, and as the war came to an end, Great Britain found that many of these submarines were no longer of use. The British Admiralty donated two to Canada, *H14* and *H15*.[40] The two submarines were received by Canada in 1919, underwent a two-year

[37] In "Submariner-speak", submarines are often referred to as "boats", while warships are referred to as "ships". The terms "submarine" and "boat" are used interchangeably throughout this paper.

[38] Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 71-75.

[39] Perkins, *The Canadian Submarine Service in Review* (St. Catharines, Ontario: Vanwell Publishing Limited, 2000). 83.

[40] Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 131.

repair and update, but were only in service from 1921 to 1922. Much like the Upholders, these second-hand boats went into an extended repair and refit before entering operational service in Canada. The submarines participated in various allied exercises off the coast of Halifax, but were taken out of service as a result of budget cuts. They were scrapped in 1925, and the submarine service was officially disbanded in 1927.[41] Finances sank these submarines just as they reached the peak of efficiency. The disbandment of Canada's submarine service in 1927 highlights how quickly a capability can be lost for the sake of economy, and how easily the decision could be made, without much by way of argument or protest. Policy-makers and submariners alike should heed these historical lessons, if such a situation comes again.

**1922-1961: The Submarine Rental Era**

The RCN remained out of submarine activities throughout World War II (WWII), but in all, twenty-seven Canadians from the RCN Voluntary Reserve became Canadian submariners who trained and sailed in allied submarines. Throughout WWII, the RCN was desperate to have submarines to train its fleet, but procurement of Canadian submarines was never seen to be convenient. At the end of WWII, the British Admiralty ordered that any surrendered German U-Boats be sent to the nearest Allied port under Operation ADIEU, two of which reported to Canadian ports in Nova Scotia and Newfoundland, *U-190 and U-889.*[42] The RCN recalled its submariners serving with allied submarine forces to crew the two submarines. *U-190* was old and worn out from the war, but *U-889* was a Type IXC U-boat that Germany had been using for experimental work, and was therefore fitted with very interesting technology.[43] Unfortunately for

[41] Julie H. Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 132-136.
[42] Julie H. Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 249-255.
[43] Derek Waller, "U-Boats in the RCN," *Argonauta* XXXV, no. 4 (2018). http://www.forposterityssake.ca/RCN-DOCS/U-Boats-in-the-RCN-by-Derek-Waller.pdf.

the RCN, in December of 1945 the Tripartite Naval Commission allocated *U-889* to the US. *HMCS U-190* was only in service in Canada for two years, and was used mostly for publicity before being scuttled in 1947.[44] It would be a stretch to state the Canada's submarine service had been reborn.

In the years after the war, Canada embraced a specialization in ASW, as an important contribution to NATO. In an ASW role, it seemed all-too-obvious that Canada would own submarines and that the submarine service would officially be reborn, but it was not to be just yet. Between 1945 and 1959, Canada rented submarines from both Great Britain and the US to develop and maintain its ASW expertise, and uphold its ASW commitment to NATO.[45] In 1959, Canada agreed to purchase one submarine from the US, although it was hardly enough to continue ASW training on both the East and West Coasts. So Canada continued to rent submarines from Great Britain to support these activities.

*HMCS GRILSE* arrived in 1961 and was based in Esquimalt. The diesel-electric submarine was certainly not the most modern type. It had been launched in 1943 and served in the US Navy as *USS BURRFISH,* participating in various patrols in the last two years of WWII and completing multiple Mediterranean deployments in the US before being sold to the RCN.[46] It lacked a snorkel and therefore had extremely limited submerged endurance as it needed to surface frequently to run the diesel-generator required to recharge its batteries. Despite its limitations, *HMCS GRILSE* was worked hard as a training boat, used to train Canadian submariners, and

[44] Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 253.
[45] Joel Sokolsky, "A One Ocean Fleet : The Atlantic and Canadian Naval Policy," *Cahiers De Géographie Du Québec* 34, no. 93 (1990), 299-314. https://www.erudit.org/en/journals/cgq/1990-v34-n93-cgq2665/022129ar.pdf.
[46] Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 279-281.

sailed extensively on training missions with Canadian and allied ships before being returned to the US and scuttled in 1969.[47]

**1962-2000: The Oberon Class**

In the late 1950s, Canada seriously considered purchase of nuclear-powered submarines. The technology had been developed in the mid-1950s, and the US was then operating three-such submarines. Canada considered this evolution of submarines to be critical to its ASW role, and explored acquiring nuclear-powered submarines for the RCN. In 1959, the Chief of Naval Staff (CNS) submitted a proposal to the Government of Canada for purchase of 12 SSNs.[48] Knowing that the sticker-price of each boat was likely to be highly unpalatable, the CNS included the alternative option of conventional diesel-electric submarines as a suitable substitute in the proposal. The comparative costing showed the conventional submarine to be $54 million less expensive per unit than the nuclear option.[49] This gave government officials an *easy-out* on the nuclear option, and weakened the nuclear proposal significantly. In 1960, the alternative proposal of purchasing conventional submarines was accepted, albeit only six to eight submarines approved and budgeted, not the 12 originally requested.

The 1960 approved purchase of new submarines suffered years of delay before any new submarines arrived in Canada. Despite Canada's commitment to ASW, a change in government and a new MND required the decision to be revisited on a number of occasions, and in 1963 the Cabinet finally approved purchase of three Oberon Class submarines from Great Britain.[50] The

[47] Canada, "Hmcs Grilse," https://www.canada.ca/en/navy/services/history/ships-histories/grilse.html (accessed 1 February, 2021).

[48] Perkins, *The Canadian Submarine Service in Review* (St. Catharines, Ontario: Vanwell Publishing Limited, 2000). 141.

[49] Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 272.

[50] Perkins, *The Canadian Submarine Service in Review* (St. Catharines, Ontario: Vanwell Publishing Limited, 2000). 142.

first Canadian O-Boat was launched in Great Britain in 1964, and a contingent of Canadian submariners arrived in Great Britain to oversee the remainder of construction and begin training on this new class of submarine.

On 22 April 1966, the First Canadian Submarine Squadron (SUBRONONE) was born in Halifax, Nova Scotia.[51] The first O-Boats arrived in Halifax three months prior, and by mid-1968 all three Canadian O-Boats had arrived in Halifax. The remaining problem was that all three new submarines were stationed on the Atlantic Coast, leaving the Pacific fleet needing to find an alternate solution while *HMCS GRILSE* was aging and required significant investment to keep afloat. The cost of a fourth O-Boat was unpalatable, so the RCN looked to the US Navy for options. The Americans offered the RCN the *USS ARGONAUT*, a Tench-Class conventional submarine that had been launched in 1944 and had recently returned from a three-year deployment in the Mediterranean. After being purchased by the RCN and commissioned *HMCS RAINBOW* (the second Canadian vessel of that name), it immediately went into a deep maintenance period of eight months due to significant repair requirements.[52] The arrival of the "new-to-Canada" *HMCS RAINBOW* cast a shadow over the loyal *GRILSE* that had served Canada well, but *GRILSE* remained alongside until 1969, used as a training platform for aspiring submariners. *RAINBOW* took on the role left behind by *GRILSE*, sailing with Canadian and allied ships in a variety of exercises, conducting ASW training and producing many new submariners before being decommissioned at the end of 1974 and returned to the USN for scrapping three years later.

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[51] For Posterity's Sake, "First Canadian Submarine Squadron - SUBRONONE," http://www.forposterityssake.ca/Navy/SUBRONONE.htm#:~:text=1ST%20CANADIAN%20SUBMARINE%20SQUADRON&text=First%20Canadian%20Submarine%20Squadron%20was,Operations%20Group%20Five%20(MOG5). (accessed 6 February, 2021).

[52] Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 307-308.

In the early years of the O-Boats, these new submarines took over the role of *targets* for the RCN's ASW training. However, through this role, the O-Boats were able to demonstrate their capabilities, and were soon tasked by headquarters with a variety of operational missions. They conducted surveillance patrols in Canadian Atlantic shipping lanes, monitoring shipping activities on and below the water, they completed covert operations, as well as national and international exercises. The O-Boats were operated on a 16-week cycle, ten weeks at sea, four weeks of maintenance and repairs, and two week of *work-ups.*[53] This 16-week cycle was repeated for a period of 16 months, at which time the submarine would be docked for more extensive maintenance, repairs, and upgrades.[54] The limited number of qualified submariners meant that a typical submariner, in the latter half of the 1980s, spent approximately twice as much time at sea per year than did a surface sailor. Canada's small fleet of submarines became work-horses, conducting *the business* at sea on behalf of Canada. The submariners formed a tightly knit community of sailors and officers who were bonded through hard work and months of living together in the confines of the small submarine, conducting top secret operations.

In 1968, the Canadian O-Boats were among the best conventional submarines in the world, and served Canada well at home and abroad for over three decades. This acquisition overcame the delays of political decision making, and was an incredible leap forward for the Canadian submarine service. They were the first new submarines purchased since *CC-1* and *CC-2* after over four decades of farming out Canadian submarine talents to its allies and having to rent and borrow submarines for its own ASW training. Canada had planned and executed the

[53] The term *work-ups* in the RCN is used to refer to a period of training evolutions conducted at sea. The submarine would have embarked an assessment team, called "Sea Training" who would put the crew through their paces, testing their responses to a variety of emergencies like floods, fires, losses of critical safety equipment, crew casualties, collisions, etc. The training regimen is aimed at ensuring the crew is operating at peak performance and is ready to tackle any emergency that may arise while as sea.

[54] Julie H. Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 311-312.

acquisition of new submarines, operated them successfully in a variety of roles, and found optimal balance between maintenance and operations. It appeared as though Canada's submarine service had found solid ground. The Oberons were an example of how Canada could buy a proven design abroad, to provide new platforms ready for immediate operational use. By the mid 1980s, the submarines were showing their age and acquiring spare parts was becoming increasingly difficult. So much so, in fact, that Canada purchased *HMS OLYMPUS* from Great Britain as a training vessel, along with *HMS OSIRIS* that had been decommissioned from the RN and was shipped to Canada in 22,050 pieces in 1993.[55] It was time to consider replacing the well-loved Oberon Class.

**2001-Present: The Victoria Class**

Work to decide on replacement submarines for the O-Boats began in the early 1980s with announcement of the Canadian Submarine Acquisition Program (CASAP). The RCN assembled a team to determine what the navy needed, and the report duly produced recommended eight to twelve submarines with under-ice capability.

The CASAP team consulted with the Australian Navy, also in the process of replacing its own fleet of Oberon submarines, who were planning to build a new class of diesel-electric boats. In 1983, members of the CASAP team visited Australia to witness the Royal Australian Navy (RAN) design review process for design selection for their new boats. Canada's intent was to collaborate with the RAN, but build its future submarines in Canada. The initial proposal to Cabinet recommended 12 diesel-electric submarines, or a minimum of four, mostly built in Canada with an estimated cost of $6 billion.[56] It took two years for that proposal to reach

[55] Julie H. Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 334.
[56] Julie H. Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 335-338.

Cabinet, and in the same year that it did, another report was released by the Sub-Committee on National Defence of the Standing Senate Committee on Foreign Affairs, *Canada's Maritime Defence*, which stated the navy needed 17 submarines, or an absolute minimum of ten.[57] There appeared to be much support for submarines in the government, and with that CASAP set out to Australia. During their visit, CASAP discovered issues with the RAN process. The RAN was later found guilty of colluding with two firms to rig the evaluation process, so CASAP abandoned the notion of RAN collaboration. CASAP did, however, observe the RAN design evaluations and when they returned to Canada they felt confident that they had found suitable designs that could be built in Canada. The team quickly assembled the required proposals to secure funding and move the program into realization. Canada appeared to be on track to build its own diesel-electric submarines.

The 1984 general election resulted in the Conservative Party of Canada coming into power and they officially approved a submarine procurement, albeit for only four boats with the remainder of the 12 to be assessed at a later date. CASAP went to business, but the new MND had developed a special interest in the project, and insisted that options for nuclear-powered submarines be added to the evaluation. The MND initiated the Nuclear Submarine Option Study (NSOS), which was conducted quietly alongside CASAP, to determine the feasibility of operating SSNs in Canada. The NSOS was kept quiet for fear that those companies bidding on the conventional submarines would abandon the project. The MND even submitted the proposal to Cabinet for four conventional submarines before the nuclear study was complete, fearing major

[57] Canada. Parliament. Senate. Subcommittee on National Defence and Canada. Parliament. Senate. Sous-comité sur la défense nationale, *Canada's Maritime Defence: Report of the Sub-Committee on National Defence of the Standing Senate Committee on Foreign Affairs* (Ottawa, Canada: The Sub-Committee,[1983]).

delays in the program if the nuclear options were found infeasible like the 1960s.[58] The Minister of Finance dismissed SSNs as too expensive, and the Minister of External Affairs argued that they would upset the balance of power between NATO and the Warsaw Pact, but NSOS continued their evaluation anyways. In the end, the CASAP team studied four possible options: the German TR 1700; the British Upholder; the Dutch Walrus; and the French Rubis which was a small SSN.[59] The comparative data is summarized in Table 1.

Table 1 - CASAP Comparison Data for Submarine Contenders[60]

| | RUBIS (SSN) | TR 1700 | UPHOLDER | WALRUS |
|---|---|---|---|---|
| Submerged Displacement (Tonnes) | 2670 | 2350 | 2438 | 2800 |
| Length (m) | 72 | 66 | 70 | 68 |
| Hull Diameter (m) | 7.6 | 7.6 | 7.6 | 8.6 |
| Torpedo Tubes | 6 | 6 | 6 | 4 |
| Reload Weapons | 14 | 14 | 14 | 16 |
| Range (nm) | Unlimited | 15,500 | 8,000 | 10,000 |
| Max Speed (knots) | 25 | 25+ | 20 | 20 |
| Endurance (days) | 70+ | 70 | 49 | 49 |
| Diving Depth (m) | 300 | 300 | 200+ | 300+ |
| Crew | 66 | 32 | 48 | 45 |

While NSOS continued its feasibility study, the in-depth study of the three conventional submarines progressed. However, much delay in announcing the contending designs resulted, as the MND was working towards the new Defence White Paper, that CASAP was hopeful would clarify the priority for new submarines. The 1987 White Paper focused on re-establishing the Canadian Forces' place abroad, and placed heavy significance on defence capabilities in the

[58] Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 339.
[59] Perkins, *The Canadian Submarine Service in Review* (St. Catharines, Ontario: Vanwell Publishing Limited, 2000). 154.
[60] Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 341.

Arctic.[61] This focus on the Arctic redirected the submarine priority back to the SSN, the only option if Canada was serious about having a submarine fleet capable of under-ice operations. The potential primary contractors that CASAP had been working with on the conventional submarine review learned of this sidebar, causing much friction between them and members of CASAP. The 1987 Defence White paper was announced on 6 June 1987 in the House of Commons, and much to the shock of CASAP, SUBRONONE and the navy, it was announced that Canada would build 12 SSNs.[62] There was much speculation that the White Paper's focus on the Arctic had been a ploy to justify the SSNs, and that the MNDs own personal fascination with SSNs had biased the whole process. In the end, the NSOS report was based on fairly loose facts, and although it was meant as a preliminary feasibility study, was treated as definitive by those in the MND's circle. As such, the final White Paper in 1987 included the building of 12 SSNs, and removed the purchase of 12 conventional submarines as well as a third batch of frigates, which the MND argued was a suitable cost offset.[63] CASAP had been blindsided, and the hard work that had been done to ensure the feasibility of building the diesel-electric fleet put at risk.

Support for nuclear submarines resulted from two factors: Canadians were emotionally connected to the notion that the Arctic waterways belonged to Canada, and therefore having Arctic-capable submarines was worthwhile; and, politicians had increased interest in being able to project force into the Northwest Passage, since Canadian and American governments were in disagreement over Canada's claim to the Northwest Passage. Support was also facilitated by the notion that finances were available to build them. Defence critics argued about the dangers of

[61] Canada, *Challenge and Committment - A Defence Policy for Canada* (Ottawa: Government of Canada,[1987]).
[62] Canada, *Challenge and Committment - A Defence Policy for Canada* (Ottawa: Government of Canada,[1987]). 53.
[63] Canada, *Challenge and Committment - A Defence Policy for Canada* (Ottawa: Government of Canada,[1987]). 54.

nuclear radiation, but it seemed that the SSN project was *full steam ahead*, so much so that the MND cancelled the diesel-electric submarine program in 1987.[64] Enthusiasm for SSN stopped the conventional submarine program. Future submarine programs in Canada need to have one clear message when the time comes to seek support for procurement.

The first major roadblock on the Canadian path to SSNs came from American and European allies. The most important first step for Canada was to secure necessary technical information regarding American nuclear reactors used in the Trafalgar class, but the Americans refused to share the information, claiming that Canada was incapable of managing such a project. One can also speculate that the Americans were unhappy about the notion of Canada being able to operate submarines in the Arctic, a region where the Americans had operated freely for decades. Canada would be one step closer to justifying its claim to the Northwest Passage. The British were hesitant to share any information on its nuclear fleet, and the French were unhappy that they had originally signed on to work with Canada for a non-nuclear version of the Rubis, and now the intention had changed completely.

In response to a series of embarrassing meetings with Canadian allies, the MND decided to reorganize the submarine acquisition team, adding a new element, Chief Submarine Acquisition (CSA) that was headed by a Rear-Admiral. The CSA was outside the procurement chain of command, and was also not included in CASAP. This resulted in CASAP having two reporting authorities, CSA and Assistant Deputy Minister Material (ADM Mat). This arrangement caused confusion over who was in charge, and who was speaking on behalf of the

[64] Perkins, *The Canadian Submarine Service in Review* (St. Catharines, Ontario: Vanwell Publishing Limited, 2000). 156.

procurement project. Regardless of these challenges, the CASAP team progressed with a comprehensive analysis of two submarine options, shown in Table 2.

Table 2 - SSN Comparative Data[65]

| | French RUBIS | British TRAFALGAR |
|---|---|---|
| Price | $350 Million | $450 Million |
| Displacement (tons) | 2400 | 4730 |
| Length (m) | 79.6 | 85.4 |
| Hull Diameter (m) | 7.6 | 9.83 |
| Speed (knots) | 25+ | 32+ |
| Diving Depth (m) | 300+ | 300+ |
| Range (nm) | Unlimited | Unlimited |
| Crew | 66 | 97-102 |
| Armament (non-nuclear) | 6 x 21in torpedo tubes (carries 22 torpedoes)<br>SM-39 missiles or mines | 5 x 21 in torpedo tubes (carries 25 torpedoes)<br>Harpoon missiles or mines |
| Propulsion | Circulation nuclear reactor generating steam for 2 turbines and 1 electric motor | Pressurized water nuclear reactor generating steam for 2 turbines and two auxiliary diesels |
| Endurance | 70 Days | 70 Days |

Unlike the diesel-electric submarine design selection process, selection of an SSN had to go through analysis by the Department of External Affairs, to study the sensitivities and political ramifications of choosing one country's design over the other. This made the decision process very political, and tensions rose between Canada, Great Britain, the US, and Canadian industries who would be involved in SSN construction and maintenance. Tensions between CSA and CASAP were also at an all-time high by mid-1987, and some of CASAP's key personnel resigned.[66] Regardless of the managerial problems, both Great Britain and France sent submarines to Halifax in Fall 1987 for demonstrations.

[65] Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 351.
[66] Julie H. Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 355.

Costing the SSN procurement project proved to be a tremendous challenge, and CSA and CASAP had developed competing figures. CSA claimed the 12 SSNs would cost $8 billion, CASAP estimated $10.7 billion, and at the time of the SSN demonstration, both the British and French's quotes had risen to $530 million and $420 million respectively per boat.[67] It was clear that the SSN project would cost more than originally anticipated, but it was unclear by how much. To add to this trouble, building ships within Canada was much more expensive than building abroad, so much so that typical military procurement projects in Canada averaged 65% over budget.[68] These factors would have been exacerbated in a construction project for a class of vessels with which Canadian industry had no experience.

In spite of all the tensions, CSA and External Affairs completed evaluation of the two possible SSNs, and were ready to make a recommendation to the Cabinet. Their proposal was scheduled to be reviewed by Cabinet on 11 May 1988.[69] That meeting never happened. The meeting had been cancelled after the Treasury Board provided a briefing note to Cabinet to explain what would be discussed in the meeting. This briefing note caused concern in the Privy Council, and it is believed that private meetings occurred between the Prime Minister, the MND, and the Minister of Finance. The lack of credible costing analysis and failure to seek independent oversight on the SSN project made the procurement untenable. There were obvious tensions between CSA and CASAP, and some decisions within the recommendation seemed unfounded. This important Cabinet meeting was never rescheduled, and with that, Canada's SSN project faded away through Summer and Fall 1988. Talk of Canadian SSNs mostly disappeared. In

[67] Perkins, *The Canadian Submarine Service in Review* (St. Catharines, Ontario: Vanwell Publishing Limited, 2000). 156.
[68] Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 357.
[69] Julie H. Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 357.

April 1989, the Conservatives announced that the SSN procurement project had been cancelled as a result of budget cuts, although when questioned specifically, the Finance Minister admitted that the full reason for the program's cancellation had not been revealed to him.[70]

Cancellation was a very large blow to the Canadian submarine service. The diesel-electric procurement once so promising had been cancelled in favour of SSNs, and now the SSN project was cancelled too. End of the Cold War also meant Canada revisited the question of whether submarines were needed at all. The changed strategic picture undercut the 1987 White Paper. The 1991 Defence Policy removed emphasis on Canada's North, and included six diesel-electric submarines as part of the future naval fleet. Submarine procurement was less promising than before, listed as "some time in the future, budget permitting."[71] CASAP had been stood down in 1990, and in 1991 the Canadian Patrol Submarine Project (CPSP) was stood up to meet the new defence policy. CPSP's aim was to select a conventional submarine design to be built in Canada, and hoped to start cutting steel in 1995/96, but budget cuts resulted in further delays.

The 1994 White Paper unveiled another option that appeared budget friendly. The UK had opted for an all-nuclear fleet, and had four surplus diesel-electric boats. The proposed deal was a $750 million lease-to-own spread over eight years, but it still took until April 1998 for the deal to become official, while the Oberon Class quickly approached end-of-life.[72] Politicians, industry, and the RCN each had conflicting views of the value of these submarines and the intentions of the UK. The media still questioned whether Canada needed submarines at all. With the Upholder purchase agreement complete, and as the Oberons paid off, Canada sent

[70] Julie H. Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 361.
[71] "True North Needs Less Guarding, Ottawa Decides", *Globe and Mail*, 18 September 1991.
[72] Julie H. Ferguson, *Through a Canadian Periscope*, 2nd ed. (Toronto, Canada: Dundurn Press, 2014). 368.

submariners to the UK to work with their *new* boats, participate in reactivation of the Upholders that had been dormant for preceding years, and prepared to sail the four boats back to Canada.

After a reactivation period in the UK, the four submarines were accepted by Canada and sailed to Halifax between 2000 and 2004. On 5 October 2004, while in transit to Halifax on its maiden Canadian voyage, *HMCS CHICOUTIMI* suffered a serious fire, which injured several crew, one fatally, and left the submarine with severe damage. This terrible incident was to become a staple in nearly every media story about the Victoria class for the following decade. Once in Canada, each submarine went through a *Canadianization* maintenance period, where systems were upgraded to meet a variety of Canadian requirements. These maintenance periods were scheduled for six months, but took much longer as a result of unforeseen complexities of integrating new systems and a myriad of unplanned repairs. Despite these complexities and the long road to an operational submarine class, Canada achieved its aim of maintaining a submarine capability. Accepting submarines never designed to meet Canada's needs undoubtedly contributed to challenges that the class experienced, but the RCN and establishments that maintain and support these vessels overcame these challenges and have shown how tremendously capable they are at solving problems in the service of Canada. This has been no small task, and should be commended. Table 3 shows a summary of the activities of the Victoria Class since 2000.

Table 3 - Summary of Victoria Class Submarine Activity from 2000 to Present[73]

| | ***HMCS VICTORIA*** | ***HMCS WINDSOR*** | ***HMCS CORNER BROOK*** | ***HMCS CHICOUTIMI*** |
|---|---|---|---|---|
| *2000* | Sailed to Canada and Commissioned to the RCN | UK Reactivation | UK Reactivation | UK Reactivation |
| *2001* | CWP* | Sailed to Canada | UK Reactivation | UK Reactivation |
| *2002* | CWP | CWP | UK Reactivation | UK Reactivation |
| *2003* | Sailed to Esquimalt | Commissioned to the RCN | Commissioned to the RCN | UK Reactivation |
| *2004* | Operational | Operational - trials and training engagements | CWP | Commenced sail to Canada, suffered severe fire, delivered to Canada via lift-ship. |
| *2005* | EDWP** | Operational – exercised with USN SSN, USN Carrier Battle Group | CWP | EDWP |
| *2006* | EDWP | Operational – first parachute rendez-vous with Canadian Army Paratroopers | Operational – trials | EDWP |
| *2007* | EDWP | EDWP | Operational – international NATO exercises, OP NANOOK | EDWP |
| *2008* | EDWP | EDWP | Operational – OP CARIBBE | EDWP |
| *2009* | EDWP | EDWP | Operational – OP NANOOK | EDWP |
| *2010* | EDWP | EDWP | Operational | EDWP |
| *2011* | Operational - trials | EDWP | Operational – OP CARIBBE, Coastal transfer to Esquimalt, grounding accident | EDWP |
| *2012* | Operational - RIMPAC, first RCN submarine to fire Mk48, sinking a USNS | Operational – trials | Awaiting repairs | EDWP |

[73] Canada, "HMCS Victoria," http://www.navy-marine.forces.gc.ca/en/fleet-units/submarines-victoria.page? (accessed 1 February, 2021). Canada, "HMCS Windsor," http://www.navy-marine.forces.gc.ca/en/fleet-units/submarines-windsor.page? (accessed 1 February, 2021). Canada, "HMCS Chicoutimi," http://www.navy-marine.forces.gc.ca/en/fleet-units/submarines-chicoutimi.page (accessed 1 February, 2021). Canada, "HMCS Corner Brook," http://www.navy-marine.forces.gc.ca/en/fleet-units/submarines-corner-brook.page? (accessed 1 February, 2021).

| | | | | |
|---|---|---|---|---|
| | decommissioned target vessel | | | |
| *2013* | Operational - trained with special forces, conducted OP CARIBBE | Operational | Awaiting Repairs | EDWP |
| *2014* | Operational - RIMPAC | Docked Maintenance period | EDWP | EDWP |
| *2015* | Operational - operations with USN in the Pacific | Operational – international NATO exercises, special forces training | EDWP | Commissioned to the RCN. Operational – trials and training |
| *2016* | EDWP | Operational – international training exercises | EDWP | Operational – training |
| *2017* | EDWP | Operational | EDWP | Operational – OP PROJECTION |
| *2018* | EDWP | Operational – OP PROJECTION in the Mediterranean and international NATO exercises. | EDWP | Operational – OP PROJECTION (197 days at sea, longest deployment of the class) |
| *2019* | EDWP | Docked Maintenance Period | EDWP | Docked Maintenance Period |
| *2020* | EDWP | Docked Maintenance Period | EDWP | Awaiting EDWP |
| *2021* | Operational - Sailed for trials and TGEX 2021 | Operational | EDWP | Awaiting EDWP |

*CWP = Canadianization Work Period
**EDWP = Extended Docking Work Period

The table shows that the Victoria Class have participated in a multitude of international and domestic training exercises, as well as international operations. The table also shows the length of time each submarine spent in major repair periods, with Extended Docking Work Periods (EDWP) ranging from five to ten years in length. Context is important here. *HMCS VICTORIA's* 2005-2010 EDWP was the first major work period conducted by the Fleet Maintenance Facility (FMF) in Esquimalt, the first of this class but also the first major submarine work period conducted there since *HMCS RAINBOW*. Similarly, *HMCS WINDSOR's* 2007-2011 EDWP was the first major work period of the Victoria class conducted in FMF in Halifax.

*WINDSOR*'s EDWP was the shortest of the four conducted, which speaks to the corporate knowledge in Halifax regarding submarine maintenance, in an organization that conducted the majority of the maintenance for the Oberon class. *HMCS CHICOUTIMI's* 2005-2014 EDWP was the first of class to be conducted through contract with Babcock Canada at Victoria Shipyards, and was complicated as a result of significant damage done by the 2004 fire. *HMCS CORNER BROOK's* 2014-2021 EDWP was complicated as a result of damages that occurred in a 2011 underwater grounding, and the fact that *CORNER BROOK* sat alongside waiting to conduct its EDWP for two years with minimal maintenance while it waited for *CHICOUTIMI's* EDWP to be completed.

Each submarine has a unique circumstance that resulted in the EDWPs being longer than scheduled, and although much of this is justifiably unforeseen, it is something that the RCN must analyze as Canada starts to consider what might come after the Victoria Class. A submarine must be maintained to an extremely high standard due to the hazardous nature of submarine operations. The RCN has maintained this high standard despite public and political pressures to expedite putting submarines to sea. The RCN's fortitude in this measure is commendable because there is immense pressure to demonstrate successes in the submarine program, but the RCN has refused to take unnecessary risks to appease politicians or create *success stories*. Assuming that the RCN's future submarine procurement is built for Canada based on minimally modified MOTS design, then the difficult challenges that the RCN has overcome with the Victoria class will serve to strengthen the capabilities of the enterprise to sustain an operational submarine fleet. If Canada can manage to put second-hand and heavily modified submarines to sea, then there is no telling what it can do with new submarines built for its desired roles. The Victoria class is currently

expected to remain in service until the mid-2030s, with planned modernization to occur in the 2020s that was called for in SSE.[74]

The history of submarines in Canada has been a long and winding path, one of vacillating public and political support, with times of immense success as seen with the Oberon class, times of immense struggle such as the *submarine rental era*, and, most recently, times of uncertainty with the Victoria Class. Now Canada faces a familiar challenge. With the Victoria class nearing end-of-life, Canada and the RCN must determine what the future of the Canadian submarine service will be. Does Canada still need submarines? If so, what will replace the Victoria class, and what changes can the RCN make to overcome the challenges experienced by the Victoria class over the last two decades?

[74] Canada, *Strong Secure Engaged* (Canada: Department of National Defence, 2017b).

## CHAPTER TWO: CANADA NEEDS SUBMARINES

Canada needs submarines for many reasons. Some are based on geography and enduring political factors, while others evolve in response to issues such as technology and changing global competition. These factors play a role in determining Canada's next submarine, while acknowledging that some roles are outside the scope of Canada's submarine program. The hard truth is that Canada's projected defence budget is unable to support an optimal solution, the all-singing-all-dancing submarine, capable of operating at home, abroad, under the ice, projecting force at sea and on-land. So Canada must evaluate the need for submarines and prioritize the roles of the future submarine program.

Submarines have been, and will continue to be a vital asset to the RCN for protecting and defending Canada's vast ocean estate, and have played an important role in Canada's contribution to the NATO alliance since WWII. As the future of maritime warfare is increasingly being driven underwater, the importance of submarines will continue to grow. To remain a credible component of the RCN, Canada's next fleet of submarines will be needed to monitor and defend Canada's two primary coasts, have some capability to operate in the Arctic, be interoperable with Canada's special forces as well as with other RCN assets and with Canada's allies, and to operate in support of Canada's maritime defence or that of Canada's allies.

### The Enduring Justification for Submarines

Canada is a large coastal state with maritime interests, in terms of both geography and trade. It borders three oceans and has the longest coastline in the world, measuring over 240,000 kilometers.[75] Canada's ocean estate incorporates the exclusive economic zone and extended

[75] Canada, "International Perspective," https://www150.statcan.gc.ca/n1/pub/11-402-x/2012000/chap/geo/geo01-eng.htm (accessed 4 March, 2021).

continental shelf and covers approximately 7.1 million square kilometers. That portions of the coastline and ocean estate reside in the ice-covered Arctic was once a suitable justification to defer security investment. However, climate change makes northern maritime routes passable for longer periods of the year, and international interest in use of the Northwest Passage has increased. In time, this trend shall force the CAF to exert a larger presence there. It is widely speculated that US and Russian submarines pass through what Canada considers internal Canadian waters, and there is little, if anything, that Canada can currently do about it, nor should it if intentions are friendly. The importance of Canada's maritime regions depends on what occurs there. Over 90 percent of the world's goods are moved on the oceans, and Canada's maritime industry generates roughly $10 billion per year in exports of commodities and trade.[76] The security of the maritime domain affects Canadians, industry, Canada's trade partners, and impacts Canada's overall national security as well as that of its primary ally, the US. It is vitally important that Canada understands what is occurring on and under its ocean estate.[77] This requires Canada to be capable of identifying and intercepting illegal activities in its own waters, and to contribute proportionately to the security of North America with its American partner.

If Canada is a large coastal state with maritime interests, why are submarines needed to ensure maritime security? Submarines offer four elements that cannot be provided by surface warships or aerial surveillance: stealth, endurance, freedom of movement, and flexibility.[78] Stealth makes the submarine a formidable deterrent. The mere possibility of a submarine operating in Canadian waters can impact the decision-making of an adversary across the entire

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[76] Canada, "Maritime Commerce Resilience," https://tc.canada.ca/en/marine-transportation/marine-security/maritime-commerce-resilience (accessed 4 March, 2021).

[77] Canada, "Maritime Domain Awareness," https://tc.canada.ca/en/marine-transportation/marine-security/maritime-domain-awareness (accessed 4 March, 2021).

[78] Cdr Michael Craven, " A Rational Choice Revisited - Submarine Capability in a Transformational Era," *Canadian Military Journal* (2006), 21-32. 22.

maritime domain.[79] Submarines give Canada the capability to exert sea control over vast ocean areas, larger ocean areas than the submarine is actually capable of patrolling regularly. Thus, the submarine has significant value because an adversary is extremely unlikely to know exactly where the submarine is patrolling, and must therefore make decisions based on the *possibility* that a submarine is in the area. Surface ships, by way of contrast, can be detected through a spate of sensors from vast distances, giving adversaries advanced warning of their presence. The submarine is incredibly hard to detect, and its crew and sensors work together to help the submarine find thermal layers in which it can easily hide from adversaries.[80] Endurance allows the submarine to travel great distances and lurk undetected for long periods. This capability is an important asset for Canada's geography, where patrolling in or near the Arctic border would require the submarine to travel north, conduct its patrol, then return home without external support for supplies or fuel. The Victoria Class have an endurance of approximately eight weeks and a range of 8,000 nautical miles (nm) at 8 knots, allowing a boat to remain on station in surveillance, loitering, and intelligence gathering roles.[81] Freedom of movement allows the submarine to "prosecute an assigned mission to successful completion without being visible to other nations or the Canadian people – an invaluable asset when discretion in military action is needed."[82] The submarine's inherent flexibility is demonstrated in the range of tasks performed. Submarines operate in open ocean or littorals without detection, can be used to gather intelligence, insert special forces in contested areas, or provide lethal offensive action. The

[79] Canada, *Leadmark 2050 - Canada in a New Maritime World* (Canada: Department of National Defence, 2016b). 39.

[80] This insight comes from the authors own experience as a Control Room watchkeeper in the Victoria Class submarines.

[81] Canada, "Victoria Class Submarines," https://www.canada.ca/en/department-national-defence/services/procurement/victoria-class-submarines.html (accessed 4 March, 2021).

[82] Canada, *Leadmark 2050 - Canada in a New Maritime World* (Canada: Department of National Defence, 2016b). 39.

degree of flexibility is highly dependent on the submarine type and equipment fit. Nuclear submarines have nearly unlimited endurance and have no need to broach the surface to recharge batteries like the conventional diesel-electric submarine does, giving them increased stealth and the capability of operating under the Arctic ice. Very small conventional submarines may have limited ability to embark special forces, but have the advantage of being able to transit in very shallow waters without detection. The Victoria class, large for a conventional submarine, is somewhere in the middle. It is large enough to embark special forces, small enough to transit submerged in littoral areas, but is incapable of operating under Arctic ice. Whatever Canada determines to be the critical roles of the future submarine fleet will determine the type, size and equipment fit required.

Canada's long standing alliances with the US, NATO, and Five Eyes must also be considered. Canada's decision to operate submarines has implications for information sharing and upholding Canada's promised alliance contributions. The contribution of submarines to Canada's intelligence sharing capability is often cited in arguments both for and against Canadian submarines.[83] It is a difficult subject to justify because, by its very nature, the valuable intelligence shared is classified. The largest collaboration of information sharing is between the Five Eyes Intelligence Community, Canada, US, UK, Australia, and New Zealand. Although actual agreements between these nations are not publicly available, it is understood that each of the five nations monitors sources of intelligence in assigned areas of the globe. Canada monitors intelligence in the north through Canadian Forces Station Alert, as well as using assets to collect

[83] For example, Byers argues that this information sharing would occur through other alliance arrangements in Michael Byers, "Does Canada Need Submarines?" *Canadian Military Journal* 14, no. 3 (2014), 7-14. http://www.journal.forces.gc.ca/vol14/no3/PDF/CMJ143Ep7.pdf. 11. Craven argues that submarine ownership admits Canada to an exclusive intelligence-sharing community in Craven, " A Rational Choice Revisited - Submarine Capability in a Transformational Era," *Canadian Military Journal* (2006), 21-32.

intelligence in the northern areas of the Atlantic and Pacific oceans.[84] Submarines fulfill a part in this intelligence gathering. Stealth and endurance allow them to monitor activities without influencing the activity, for an understanding of behaviours and intentions. Gaps in operational availability of the Victoria class has weakened this argument, but choosing not to have submarines at all would significantly impact Canada's ability to information share in this regard, and make Canada the only Five-Eyes nation without submarines. Without the capability to offer such intelligence, Canada can hardly expect to be given this information in kind. The intelligence gathering capability of submarines strengthens Canada's position in alliance relationships with the US, Five-Eyes, and NATO.

Submarine ownership also greatly contributes to Canada's position in the NATO alliance. Participation and reliance on such alliances has been a backbone of Canadian defence policies since the 1964 White Paper.[85] Canada, as a middle-power with a small professional armed forces, lacks the resources to sustain a defence force capable of defending against the entire threat spectrum. This limitation is as true today as it was in WWII. As such, Canada contributes specific capabilities to its alliances, ensuring that other capabilities, not possessed by Canada, would be provided if needed. Since the end of WWII, major RCN procurements have prioritized Canada's ASW capabilities, procurements that ensured Canada maintained a high skill level as well as the ability to train its allies. Submarines play an important role in this effort for three reasons: ASW training of Canada's surface sailors; ASW training for Canada's allies; and to conduct ASW in actual conflict, because the best defence against an enemy submarine is a

[84] BGen (Ret'd) James Cox, "Canada and the Five Eyes Intelligence Community," *Open Canada,* 18 December, 2012, .

[85] Canada, *White Paper on Defence 1964* (Ottawa: Canada,[1964]). 6. Canada's reliance on alliances as part of the overall strategy for the defence of Canada has appeared in each defence policy, white paper, or defence update since 1964, including: *Defence in the 70's; Challenge and Commitment – A Defence Policy for Canada* (1987); *Defence Update 1988-89* (1989); *1994 White Paper on Defence; Canada First Defence Strategy* (2008); and *Strong, Secure, Engaged – Canada's Defence Policy* (2017).

submarine of your own. ASW has been a significant factor in Canada's contribution to the NATO alliance since 1949, and has played a role in Canadian defence policies ever since.[86] Failure to uphold Canada's ASW excellence would weaken its position in these alliances, especially considering that Canada's defence spending does not meet the 2014 agreement between NATO countries to spend two percent of gross domestic product on defence.[87] Submarines are a critical contribution to Canada's alliances. Without them, Canada would be relegated to a second-class alliance contributor and its ability to defend the homeland, either independently or with allies, would be significantly degraded.

Canada has always needed submarines because it has a vast ocean estate that is too large to be monitored continuously by surface or air assets. With submarines, adversaries must consider that a submarine *could* be there, even if undetected. The submarine has the advantage of influencing vast spaces, without necessarily patrolling all of them. Canada has used submarines for the last 70 years as a contribution to its alliances. Alliances play a critical role in Canada's defence strategy, a strategy that is unlikely to change in the foreseeable future.

**The Evolving Reasons – The Future of the Maritime Domain**

The future of conflict and competition in the maritime domain is increasingly underwater. Technological advances in long-range, precision guided anti-surface missiles, and long-range radar along with space-based surveillance tools has increased the risk involved in the work and survivability of the surface navy.[88] These technologies make surface ships easier to find and

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[86] Sokolsky, "A One Ocean Fleet : The Atlantic and Canadian Naval Policy," *Cahiers De Géographie Du Québec* 34, no. 93 (1990), 299-314. https://www.erudit.org/en/journals/cgq/1990-v34-n93-cgq2665/022129ar.pdf.

[87] Lee Berthiaume, "Canada Set to Not Spend More on Defence, Despite US Pressure," *Global News*29 November, 2019. https://globalnews.ca/news/6236653/canada-nato-defence-spending/.

[88] Bryan Clarke and Timothy Walton, *Taking Back the Seas: Transforming the U.S. Surface Fleet for Decision-Centric Warfare* (USA: ,[2019]). 2-4.

engage at greater distances. In contrast, locating submarines remains challenging. Surface warships rely on both active and passive acoustic sensors, but active sensors disclose a ship's position to the submarine, while passive arrays are limited in range, and can be avoided by submarines through the use of acoustic decoys, quiet running modes, or maneouvering between thermal water layers. When avoiding detection to gain advantage in maritime conflict, the submarine possesses a remarkable capacity to kill or sink a ship, and do so decisively.

Most navies now recognize that the future of maritime competition is in the underwater domain. Submarine ownership, previously the preserve of the most powerful navies, in recent decades has seen smaller countries building and acquiring submarines. This trend is particularly evident in the Asia-Pacific region, where "minor powers see submarines as a cost-effective way of establishing the capability to secure their surrounding waters."[89] Today, small and large navies are investing in submarines of varying sizes and capabilities. Such submarines possess the common advantage of stealth, and give nations a tool for exercising sea control and sea denial.[90] It is estimated that over 40 countries currently operate submarines, including countries such as Taiwan, Malaysia, and Ecuador, and that number continues to grow as more countries realize the power that submarines bring to a navy and the overall cost-effectiveness of the platform. Countries like Peru and Vietnam even operate a larger number of submarines than Canada.[91] The RCN's strategic policy, *Leadmark 2050,* acknowledges this reality by highlighting that countries of all sizes are investing in advanced naval assets, stating "highly sophisticated submarines – whose ability to dominate the maritime domain is well understood by nations both large and small

[89] Andrew Davies, "Up Periscope - the Expansion of Submarine Capabilities in the Asia-Pacific Region," *Rusi* 153, no. 5 (October, 2007), 64-69. http://file:///C:/Users/studentadmin/Downloads/Up_periscope_understanding_su.pdf.

[90] Asia Pacific Defence Reporter, "The Role of Submarines in Warfare," *Asia Pacific Defence Reporter,* December, 2010, . 5-6.

[91] GlobalFirepower.com, "Submarine Fleet Strength by Country, 2021," https://www.globalfirepower.com/navy-submarines.php (accessed 6 March, 2021).

– are being acquired around the world in large numbers, especially in the Indian Ocean and Asia-Pacific regions."[92] *Leadmark* also observes that submarines can and are being used in organized crime, and the technology could extend to non-state actors to be used in other roles, like terrorism. With more nations and non-state entities utilizing submarines, and the technologies that are making surface warfare untenable, the future of maritime warfare is clearly in the underwater domain. Canada, as a highly capable ASW navy, needs submarines of its own to remain an expert in it.

Today's global power competition is real, and the maritime domain plays a critical role. In terms of global trade, geographical areas of dispute, and dominance exertion, the major global powers of the US, China and Russia, as well as others striving to be considered in this rank like India and Brazil, are all investing in navies and developing flotillas of modern submarines. A 2018 US Congressional Research Report indicates that China has modernized its navy over the last 25 years, and that it would be considered a formidable adversary for US naval forces. China has an estimated 65-70 submarines, most of which are diesel-electric, and has been replacing older submarines with modern ones on a nearly one-for-one basis, which is likely to continue through this decade.[93] This same report indicates that China's navy is operating further from home ports, including the Western Pacific, Indian Ocean, and waters around Europe.[94] Although the likelihood that Canada would find itself in direct conflict with China seems low, Canada's contribution to the preparedness of its allies in such a conflict is a significant political bargaining

[92] Canada, *Leadmark 2050 - Canada in a New Maritime World* (Canada: Department of National Defence, 2016b). 7.

[93] Ronald O'Rourke, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress (USA: C*ongressional Research Services,[2021]). 8-9.

[94] Ronald O'Rourke, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress (USA: C*ongressional Research Services,[2021]). 2.

chip. The US often capitalizes on exercising with Canada's diesel-electric submarines, as it has none of its own, and the operational considerations of a conventional submarine are different than that of a nuclear-powered one. China's naval forces operating around European waters could affect Canada's other alliances, and the value of contributing submarines to a naval effort for any alliance is significant.

If China seems too far away, then consider Russia. Russia as a maritime threat may seem like a problem of the Cold-War era, but between 2008 and 2018 Russia increased military spending by 230%, and for reasons of geography and politics, this should be something Canada pays attention to.[95] Russia has recognized the strategic and economic significance of its Northern Sea Route, and has become the "foremost military and shipping leader in the circumpolar region."[96] Part of this militarization effort includes six types of submarines, both nuclear-powered and diesel-electric.[97] Russia's nuclear fleet is capable of operating in both Russian and Canadian Arctic maritime regions. With Russian President Vladimir Putin focused on bringing Russia back into the global power competition, the Arctic is an area where Russia exerts significant dominance, with northern military bases, and an arctic capable military. The West, including Canada, should pay attention.

For Canada, this changing strategic environment means strengthening its military's arctic capabilities. SSE puts Canada on a path to increased Arctic capability, but the maritime component remains small. The Arctic Offshore Patrol Vessels have limited ice-operation capability, but are not designed to operate in the deep north, or the Northwest Passage year round.

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[95] Christopher Coker, "The West and Russia - another Front in the New Cold War?" in *Strategic Challenges in the Baltic Sea Region - Russia, Deterrence and Reassurance*, ed. Ann-Sofie Dahl (Washington, USA: Georgetown University Press, 2018), 49-58.

[96] Ron Wallace, *The Arctic is Warming and Turning Red - Implications for Canada and Russia in an Evolving Polar Region* (Canada: Canadian Global Affairs Institute, 2019). 1.

[97] "6 Types of Submarines:The Russian Navy's Extreme Modernization." *Forbes,* June, 2020a, .

Nuclear submarines can. While it might be a stretch to say that Canada's next submarine fleet should be nuclear powered, it should not be off the table for the submarine fleet-after-next. As history has demonstrated, selling the nuclear-powered option has been unsuccessful on multiple occasions, and there is no reason to believe it would be an easier sell now. In order to be in a position to even consider acquiring nuclear submarines, Canada must first show significant improvements in its management of a conventional class. The fleet-after-next is likely 40 to 50 years away, by which time alternate green technologies that would allow under-ice operation could be more feasible. For now, technologies such as air-independent-propulsion (AIP) are likely a suitable stepping stone, as they offer a modern technology with improved stealth characteristics, and the potential for limited under-ice operation capability.[98]

*Leadmark 2050* provides a set of capability requirements for the Victoria class successor:

> From the operational perspective, the considerations likely to emerge as important elements in the acquisition of a successor submarine include the ability to contribute to joint operations in the littorals through a broader range of strike weapons, intelligence, surveillance and self defence capabilities than are resident in the *Victoria* class. Also critical is an enhanced capacity to host, insert, support and extract special operations forces; the ability to remain fully connected to naval operational networks at depth and speed; the ability to operate and recover autonomous underwater vehicles; and the ability to operate even more covertly, using air-independent propulsion. Among the key strategic considerations for the replacement submarine will be the ability to operate in all three of Canada's ocean environments, specifically the unique requirements and design elements associated with operations under ice.[99]

To achieve the capability requirements that *Leadmark* has identified, Canada must consider a submarine with range capabilities equivalent or better than the Victoria class. Most navies operating conventional submarines use them for short-range continental and coastal

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[98] Simon Summers, "Air-Independent Propulsion: An Enabler for Canadian Submarine Under-Ice Operations?" Canadian Forces College, Toronto, Canada, 2018).

[99] Canada, *Leadmark 2050 - Canada in a New Maritime World* (Canada: Department of National Defence, 2016b). 50.

defence, meaning that submarines can operate at short ranges from supply bases and are not necessarily required to have ocean-crossing range. In Canada, deliberate intentions to operate in the far north requires Canada's submarines to have a large enough range for a return trip to the Arctic, as there is currently no infrastructure to support a submarine stopping for fuel and resupply in the north. A return trip from Halifax to northern Baffin Island is approximately 5,000 nm plus the range required to conduct a patrol on station.[100] This range exceeds the distance required to cross the Atlantic, or to sail from Esquimalt to the Hawaiian Islands. In this regard, Canada's future submarines require the range to be capable of global deployment, whether Canada intended to deploy them globally or not.

In modern conflict, the notion that the vast expanse of oceans provides a credible defensive buffer to overt acts of hostility by Canada's adversaries is an utter fantasy. As the range, speed, and lethality of weapon systems increases, navies will progressively need to operate further from home shorelines to defend Canadian sovereignty. In this regard, Canada's Navy must be capable of confronting potential enemies far beyond Canada's territorial waters. This means having the capacity to independently transit and operate in an adversary's waters in order to ensure the sanctity of our own shorelines. Furthermore, future naval engagements will certainly unfold in a highly contested anti-access and area denial (A2/AD) environment. In this context, Canadian and allied surface fleets will rely on submarines to first sweep the area, develop an understanding of the enemy's defence through the employment of special forces or modern ISR capabilities, and ultimately support actions to deter or defeat potential threats. Submarines have a greater chance of survivability than surface ships in contested threat environments, so by

[100] "Sea Distances."https://sea-distances.org/ (accessed 16 March, 2021).

default will form the backbone of any RCN response. Consequently, Canada's submarines shall need to have the endurance, stealth, and capabilities to operate in these hostile waters.

Evolution of the maritime domain over the last few decades has placed increased importance on the underwater domain. Navies large and small are recognizing this reality, and are procuring submarines. Canada, in support of its allies and for its own defence, needs submarines in the naval inventory to be able to remain competitive on a global scale, and to maintain a mastery in the underwater domain.

**Canada's Future Submarines**

So how do justifications for submarines translate into realistic roles for Canada's submarine fleet? Canada has tried twice to reconcile the strategic importance of the Arctic with a nuclear submarine program, and twice the programs have failed. The program is more expensive than is palatable, has high political hurdles to overcome to be admitted into the nuclear propulsion community, and, frankly, the Canadian public likely does not think the RCN could manage a nuclear submarine program. So if Canada is going to use the Arctic justification, it must look to technologies like AIP, which could give limited under-ice capabilities.

Setting aside a full under-ice capability, the enduring and evolving reasons that Canada needs submarines in conjunction with requirements detailed in *Leadmark 2050* can be combined to form a list of roles that Canada's future submarines will need to fill:

a) Patrol Canada's coastlines in all three ocean borders;
b) Be able to detect, track, and intercept vessels of interest;
c) Embark, insert and extract special forces;
d) Conduct intelligence, surveillance and reconnaissance in support of Canadian interests and that of its allies;

e) Be capable of joint operations, and remain connected to joint communication networks while submerged and at speed;
f) Be globally deployable; and
g) Operate and recover autonomous underwater vehicles.

This set of capability requirements, though far from exhaustive, suggests that Canada's next submarines will retain all the capabilities resident in the Victoria Class, while adding new capabilities like under-ice operation, submerged communication, and hosting autonomous underwater vehicles. Global deployment, in support of exercises and operations with allies as well as special forces insertion, requires that the next submarine have *at least* the same range and endurance as the Victoria Class. A relatively large, AIP submarine with these capabilities is not unimaginable, and so long as they are procured in the right number, and supported by a submarine enterprise that can reliably maintain and crew them, these submarines will be a tremendous strategic and operational asset for Canada. The next obvious question is, what submarine should it be?

## CHAPTER THREE: THE VICTORIA CLASS SUCCESSOR

Procurement represents the first step in a series of requirements to ensure that Canada retains a submarine capability. But getting the first step right is imperative. Understanding firmly the roles of the submarines is a necessary starting point to determine tangible and quantifiable requirements. From those tangible requirements, Canada and the RCN can evaluate available and proven submarine designs according to established needs, not wants. In addition to capabilities drawn from roles previously discussed, the RCN must quantify required characteristics such as range, endurance, and crew size. Range is driven by Canada's need to patrol vast coastlines, particularly if Canada intends to have some Arctic capability. A hypothetical Arctic patrol could see a future submarine traveling from Halifax harbour to the inlets of Baffin Bay, a 2,400 nm journey that would take nearly two weeks to get on station. If a ten day patrol is assumed at a speed of five knots, then the entire mission would require an endurance of 40 days, and the distance travelled would be 6,000 nm. With this general operational profile, estimated range and endurance can be assumed with some added range to ensure a margin of operational flexibility.

Crew size depends on a variety of variables. Larger submarines tend to have larger crews, and some are designed with higher automation which allows for smaller crews. As a baseline, it can be estimated that crew sizes should be comparable to the Victoria class. These considerations, as well as the roles previously identified, lead to the following set of requirements:

- Range: 7000+NM;
- Endurance: 40+ days;
- Crew: approximately 50 personnel;
- Propulsion: AIP;

- Advanced communications with submerged capability;
- Special forces deployment and recovery capability;
- UUV deployment and recovery capability; and,
- Torpedo tube compatibility with US Mk 48 heavyweight torpedoes

Characteristics such as submarine size, range, endurance, crew size, propulsion details, and special forces deployment capabilities are typically available through open source resources, whereas specifications such as Mk 48 compatibility and the details of communications capabilities are not. The analysis herein relies on open source information to derive a comparative analysis of several commercially available submarine design options that may suit the needs of Canada.

**Submarine Procurement Options Analysis**

The RCN's future submarine should build upon the capabilities of the Victoria Class, incorporating new capabilities based on proven designs. Canada needs a flotilla of conventional submarines, with AIP for increased submerged range and potential limited under-ice capabilities for operation in Canadian waters and abroad. Technologies should be leveraged to incorporate state of the art sensor suites, combat suites based on network centric operation, and modern communication systems that allow joint and coalition operation within Canadian and allied task groups. Such submarines do exist, with varying degrees of compatibility for Canadian needs.

Canada must balance capability with maintainability, reliability, and both acquisition and through-life cost. Prioritizing a proven design over bespoke technologies ensures that the future submarine is supportable through-life with availability of spare parts and international corporate knowledge, but presents the distinct disadvantage of operating a *known* platform. Choosing a newer design might have the advantage of cutting-edge technology, but Canada would need to

ensure that contracting and through-life support was structured to mitigate the impact to cost and operational availability that can occur when components become sparse or are not widely understood.

The method by which submarines can be procured range from indigenous design and build, modified MOTS design that can be license-built in Canada, or MOTS designs built outside of Canada. Canada's most likely option for success is a minimally modified MOTS design built overseas. This is likely the least expensive procurement option, and would have fewer technical complications after acceptance. This conclusion is developed from several factors. Canada has no history with designing its own submarines, and endeavouring to develop such skill sets at this juncture would introduce intolerable risk to a future submarine procurement project. Canada's submarine demand would require only a small production run, meaning it would not be economical to design and build them in Canada. Canada must therefore capitalize on proven and available submarine designs. Although Canada does have a history of building submarines, albeit brief, this is not an industry that Canada has maintained. The National Shipbuilding Strategy, announced in 2010, makes no mention of submarine building, and the industries involved in this strategy are currently consumed with work on the RCN's future surface fleet and Canadian Coast Guard requirements, leaving no capacity for projects as complex as submarine building.[101] While there are potential Canadian shipyards that are not involved in NSS, such as Davie Shipyard, which have the capacity and motivation to participate in submarine construction, it is not economical to consider a full design and build program for submarines in Canada. For Canada to maintain its submarine capability, it must aim to have replacement submarines available starting in mid-2030, or be prepared to dedicate significant investment to keep the Victoria class

[101] Canada, "National Shipbuilding Strategy," https://www.tpsgc-pwgsc.gc.ca/app-acq/amd-dp/mer-sea/sncn-nss/index-eng.html (accessed 16 March, 2021).

operational beyond 2035, which is already more than a decade beyond the intended design life of these platforms. In 2035, the Victoria class will be four decades old, the same age that the Oberons were when decommissioned. To mitigate the possibility of any gap between the Victoria class and its successor, and to minimize the risk to cost and schedule, the RCN must select a minimally-modified MOTS design that can be built primarily overseas. This limits the potential replacement options to those that are designed and built for export by other countries. There are currently six nations with domestic conventional submarine design and build capability: Japan, Sweden, China, Russia, France and Germany. Politically, it is highly unlikely that Canada would seek Chinese or Russian options, leaving four possible contenders. While some other nations have started to offer export models of their submarines, such as Spain, priority in this analysis is given to proven designs from industries with a strong pedigree in submarine design and build in order to minimize the risk of cost and schedule creep.

Analysis of export options yields the following: the German Type 214, the French Scorpene, the Swedish Type A-26, and the Japanese Soryu. The French Shortfin Barracuda also shows considerable promise, having been selected by Australia as its replacement for the Collins class it would appear to have the requisite characteristics to meet the RCN's needs. At this time there is insufficient technical information on the Shortfin Barracuda to conduct any valued analysis in comparison to the other classes presented above. As such, when more information is made available the conclusions drawn below will need to be revisited. Examination of each of the four selected options considers where the submarines are being designed and built, for whom and for what roles, the platform's specifications and special attributes, the program or equipment risks, and finally the potential advantages and disadvantages of operating such submarines in Canada.

**German Type 214**

The German Type 214 evolved from the German Type 209 and is considered by some to be the export version of the Type 212a. The 214 operates the same AIP system as the 212a, but the Type 214 lacks many of the classified systems and most notably, the non-magnetic hull of the 212a. The Type 214 is operated by Greece, South Korea, Portugal and Turkey, with 21 Type 214's built or planned around the globe.[102] These submarines have been built by Germany for export, and have also been license-built in Greece, South Korea and Turkey. Although primarily used in continental patrol and intelligence, surveillance, and reconnaissance (ISR) roles, the Type 214 has ocean-crossing range, estimated at 12,000 nm, and can operate at depths of 400 m.[103] The submarine is equipped with eight 533 mm torpedo tubes, four of which are capable of firing missiles, and all can be used to lay mines. The Type 214 has been in operation since the early 2000s, and has since gone through a myriad of upgrades or nation-specific modifications, yielding a robust but flexible design capability that can be fitted with modern sensors and equipment packages to suit Canadian needs.

All 214's are fitted with fuel-cell based AIP systems, which give the submarine a submerged endurance of approximately two weeks.[104] The German AIP system is designed by Howaldtswerke-Deutsche Werfte (HDW), and is used in many conventional submarines around the world, making this AIP option a proven design. The submarine combines the proven technical attributes of the Type 209 with the advanced technologies of the 212a, with very high strength steel which gives it high shock resistance and impressive operating depth capabilities.

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[102] Jane's, *Papanikolis (Type 214) Class* (Online: Jane's, 2020c). Jane's, *Reis (Type 214TN) Class* (Online: Jane's, 2020e). Jane's, *Tridente (Type 214) Class* (Online: Jane's, 2020g). Jane's, *KSS-II (Type 214) Class* (Online: Jane's, 2021b).

[103] Naval Technology, "U212/U214 Submarines," https://www.naval-technology.com/projects/type_212/ (accessed 16 March, 2021).

[104] Naval Technology, "U212/U214 Submarines," https://www.naval-technology.com/projects/type_212/ (accessed 16 March, 2021).

The design is optimized for stealth and signature reduction, combining resiliently mounted decks and equipment, noise attenuating equipment enclosures, a streamlined outer hull casing, and a low signature propeller design.[105] The general specifications of the Type 214 are detailed in Table 4, and a cutaway diagram is seen at Figure 1.

Table 4 - German Type 214 Specifications[106]

| German | Type 214 |
|---|---|
| Displacement | 1845 tonnes (surfaced)<br>2023 tonnes (submerged) |
| Length | 68 meters |
| Beam | 6.3 meters |
| Draught | 6 meters |
| Propulsion/Power | Diesel-Electric + Fuel Cell AIP |
| Armament | 8 x 533 mm (21-inch) bow tubes |
| Diving Depth | 400 meters |
| Speed | 20 knots (submerged)<br>12 knots (surfaced) |
| Range | 12000 nm |
| Endurance | 80 days |
| Crew | 27 |
| Cost | $330 Million USD[107] |

[105] Guy Toremans, *HDW Class 214 Proliferation of a Frontrunner Submarine* (Online: Monch Publishing Group, 2017).

[106] Jane's, *Reis (Type 214TN) Class* (Online: Jane's, 2020e). Note: The Type 214 comes in multiple variants with unique specifications, this table is based on Turkey's variant, as the most recently built.

[107] Terence Roehrig, "South Korea: Nuclear Submarines Not Worth the Cost," https://www.lowyinstitute.org/the-interpreter/south-korea-nuclear-submarines-not-worth-cost (accessed 16 March, 2021).

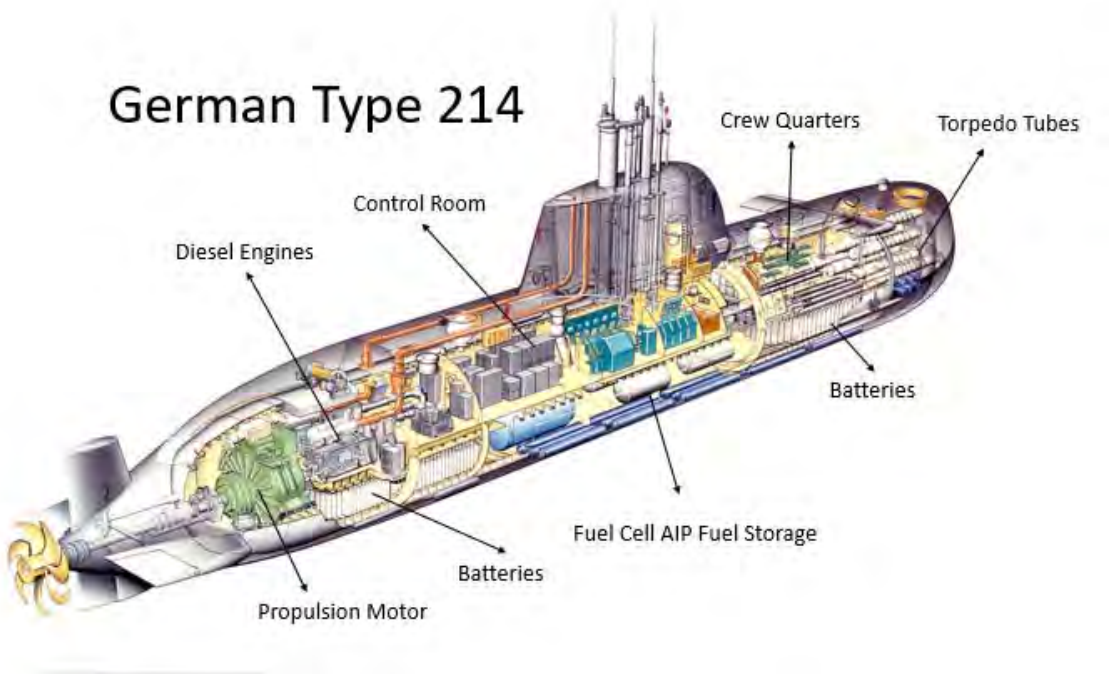



Figure 1 - Type 214 Cutaway[108]

That Type 214's have been around for nearly two decades, and that the design has been modified for multiple nation-specific requirements mitigates much of the risk that would otherwise be inherent in a new design. The proven and widely used design comes with the advantages of a presumably well-supported supply chain, which would help alleviate the high cost of bespoke components or general lack of availability of parts that has been suffered by the Victoria class. The submarine may not meet some of the RCN's desired capabilities, such as the launch and recovery of unmanned submersibles, or the ability to insert special forces and significant modifications would be required to add such capabilities. The Type 214 is a highly capable and proven platform that would meet many of the RCNs desired roles.

[108] Picture credit http://gentleseas.blogspot.com/2016/08/. Accessed 17 March 2021.

**French Scorpene**

The French designed Scorpene class is in service in Chile, Malaysia, India, and Brazil, with 14 hulls built or planned. The design has been in operation since 2005 and continues to be ordered by navies today. All 14 hulls planned and built to date are conventional diesel-electric without the AIP option.[109] The AIP capable option would require an 8 m hull plug, which would give the submarine an approximated 21 day submerged endurance. Much like the Type 214, the Scorpene does not boast capabilities related to special forces or unmanned underwater vehicles, though these adaptations may be available with expected increases in cost, risk, and project timelines. Specifications for the Scorpene class are detailed in Table 5. Although specifications vary based on nation-specific modifications, the table is based on the Brazilian model as the most recent and largest Scorpene. A diagram of the submarine is seen at Figure 2.

Table 5 - French Scorpene Class Specifications[110]

| | Scorpene |
|---|---|
| Displacement | 1709 tonnes (surfaced)<br>1870 tonnes (submerged) |
| Length | 71.6 meters |
| Beam | 6.2 meters |
| Draught | 5.4 meters |
| Propulsion/Power | Diesel-Electric, not fitted with AIP |
| Armament | 6 x 533mm (21-inch) bow tubes<br>Tube launched missile capability |
| Diving Depth | 350 meters |
| Speed | 20 knots (submerged)<br>11 knots (surfaced) |
| Range | 6500 nm |
| Endurance | 50+ days |
| Crew | 31 |
| Cost | $500 Million USD[111] |

[109] Jane's, *Perdana Menteri (Scorpene) Class (Malaysia)* (Online: Jane's, 2020d). Jane's, *Scorpene Class (Chile)* (Online: Jane's, 2020f). Jane's, *Kalvari (Scorpene) Class (India)* (Online: Jane's, 2021a). Jane's, *Riachuelo (Scorpene Brazil) Class* (Online: Jane's, 2021c).

[110] Jane's, *Riachuelo (Scorpene Brazil) Class* (Online: Jane's, 2021c).

[111] Andrew Cawley and Warren King, *Future Submarine Industry Skills Plan: A Plan for the Naval Shipbuilding Industry* (Online: Australian Government,[2013]). 36.

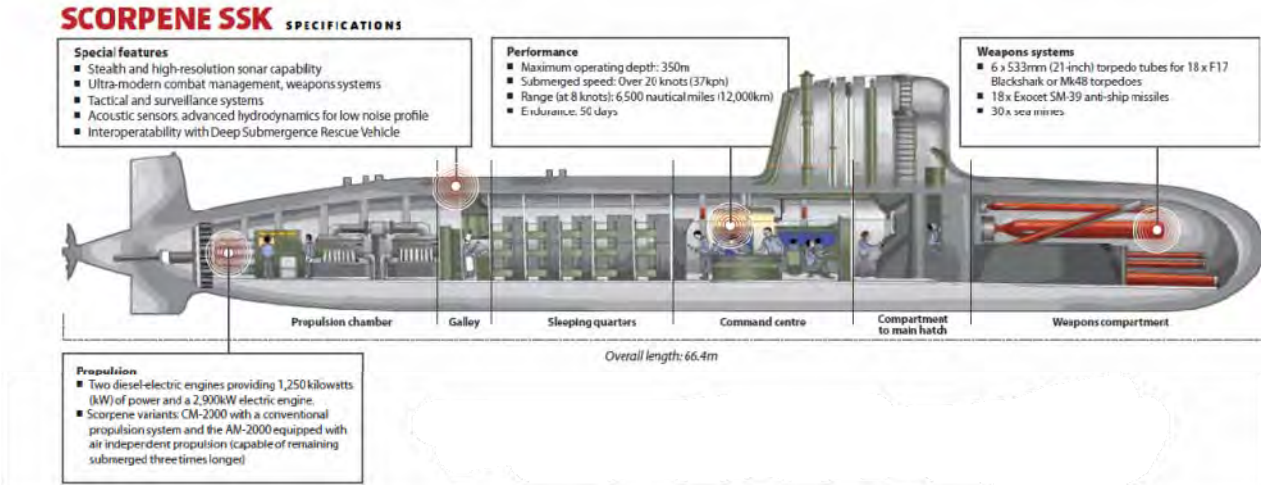



Figure 2 - Scorpene Class Diagram[112]

**Swedish Type A-26**

The Type A-26 is currently being built by Saab Kockums for the Swedish Navy. The A-26 *Blekinge class* will replace Sweden's *Gotland* class, with two A-26s scheduled to be commissioned into service in 2024 and 2025.[113] Sweden designed this submarine for operation in the Baltic Sea region, a fairly shallow arm of the Atlantic, where the average depth is 57 meters, maximum depth is 459 meters, and temperature ranges between 1°C in winter and 17°C in the summer.[114] The submarines are intended for protection of sovereign waters, defence against Russian threats in the area, and in constabulary roles against over-fishing and pollution. In the Baltic Sea region, there is also considerable threat from underwater mines, which are remnants of past wars. Driven by these characteristics, the A-26 is optimized for shallow water operation, with priority design factors being stealth and shock resistance. Although not currently in conflict,

[112] Picture credit http://gentleseas.blogspot.com/2016/08/. Accessed 17 March 2021.
[113] Jane's, *Blekinge A 26 Class* (Online: Jane's, 2020a).
[114] European Environmental Agency, "The Baltic Sea," https://www.eea.europa.eu/publications/report_2002_0524_154909/regional-seas-around-europe/page141.html#:~:text=The%20Baltic%20Sea%20has%20marked,lifeless%20because%20of%20oxygen%20depletion. (accessed 16 March, 2021).

Sweden maintains a defence posture aimed at balancing military capability, force availability, and international cooperation. The A-26 achieves this balance by incorporating cutting edge technology including significant sound attenuation from machinery, cutting edge sensors, and combat management networks, and a double Stirling AIP power plant that delivers twice the power of the Gotland plant.[115] The A-26 is a versatile weapons platform including four 21-inch torpedo tubes and a 1.6 meter flexible payload tube that can be used to lay mines, deploy remotely operated vehicles (ROV), unmanned underwater vehicles (UUV), autonomous underwater vehicles (AUV), or be used to deploy special forces. Saab also boasts that the submarine's modular design creates a futureproof design that is easy to maintain and upgrade through life cycle, and that this feature makes the design adaptable for export to other nations.[116]

To improve export potential, Saab offers the A-26 in three variants; the Pelagic, Oceanic and Extended Oceanic. The Pelagic is a much smaller, short range version, the Oceanic is the 2000 tonne version being built for Sweden, and the Extended Oceanic is larger with longer range capabilities. The Oceanic and Extended Oceanic provide the most appeal for Canadian requirements, and the characteristics of each are provided in Table 6, and artistic renderings shown at Figure 3 and Figure 4.

[115] Richard Scott, "Sweden Set to Test 'Double Stirling' AIP Plant," *Jane's International Defence Review,* 18 June, 2019b, .

[116] Saab, "Submarines," https://www.saab.com/products/naval/submarines (accessed 16 March, 2021).

Table 6 - A-26 Variant Specifications[117]

| Type A-26 | Oceanic | Extended Oceanic |
|---|---|---|
| Displacement | 2000 tonnes (surfaced)<br>2200 tonnes (submerged) | 3000-3500 tonnes (submerged) |
| Length | 65 meters | 80+ meters |
| Beam | 6.75 meters | 8 meters |
| Draught | 6 meters | Variant dependent |
| Propulsion/Power | Diesel-Electric and Stirling AIP | Diesel-Electric and Stirling AIP |
| Armament | 4 x 533 mm (21 inch) bow tubes<br>1.6 m Multi-Mission Tube<br>18 VLS tubes proposed option | 4 x 533 mm (21 inch) bow tubes<br>1.6 m Multi-Mission Tube<br>18 VLS tubes proposed option |
| Diving Depth | 200 metres | unk |
| Speed | unk | unk |
| Range | 6500 nm @ 10kts | 10,000 nm @10kts |
| Endurance | 45 days<br>18+ days submerged with AIP | 50+ days<br>18+ days submerged with AIP |
| Crew | 17-35 | 20-50 |
| Cost | $480 Million USD[118] | unk |

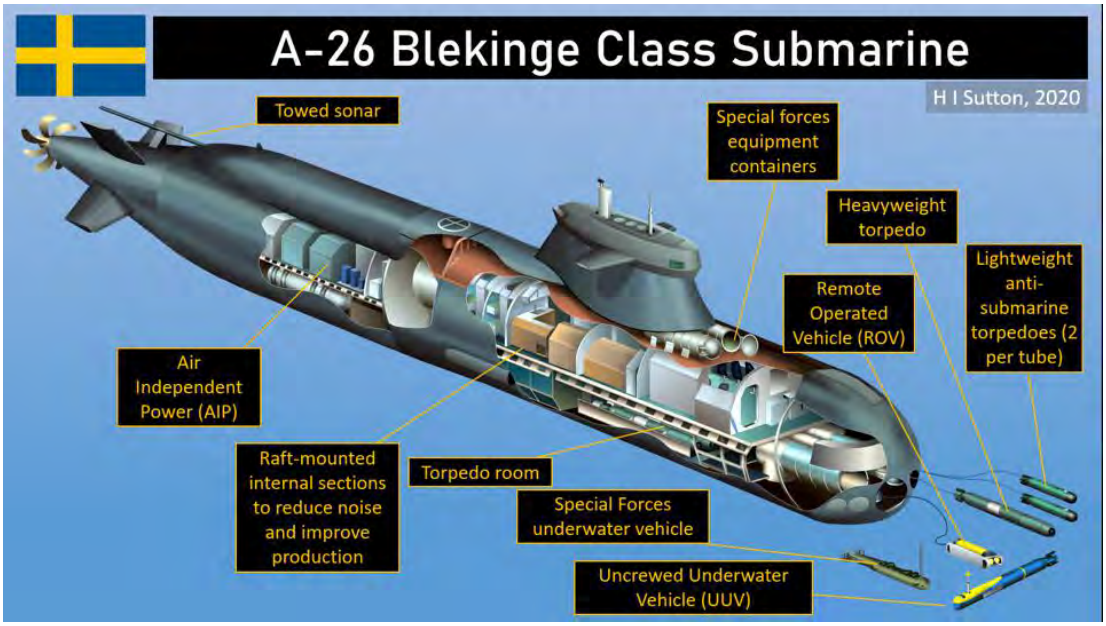



Figure 3 - Type A-26 Oceanic Artistic Rendering[119]

[117] Jane's, *Blekinge A 26 Class* (Online: Jane's, 2020a). And H. I. Sutton, "A-26," http://www.hisutton.com/A26.html (accessed 16 March, 2021).

[118] Sebastien Roblin, "This 1 Country Makes Submarines Tough, Stealthy, and Cheap (Not America)," *The National Interest,* 15 January, 2020, .

[119] Sutton, "A-26," http://www.hisutton.com/A26.html (accessed 16 March, 2021).

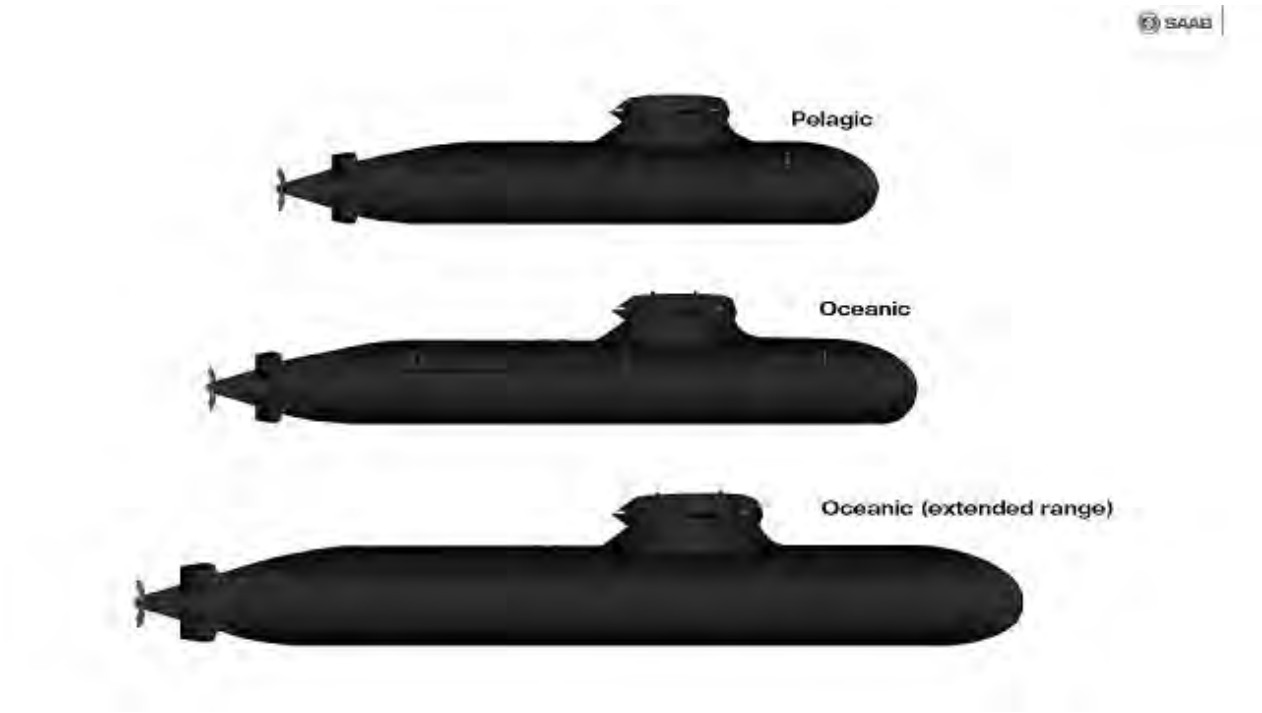



Figure 4 - Type A-26 Variants[120]

The A-26, in its oceanic or extended oceanic design, incorporates several risks that require Canadian consideration. The design is not yet proven, as none are currently in operation and only the oceanic is currently in construction-quality design phase. No other countries have purchased the design, though it has been considered by countries such as the Netherlands and Australia. The Saab Kockum business model is new. The Kockum shipbuilding industry in Sweden was previously owned and operated by Germany's ThyssenKrupp Marine Systems (TKMS), who relinquished the Kockums shipbuilding and repair industry in 2014, as the Swedish government was determined to re-establish an organic engineering and industrial capability for submarine design and build. The TKMS sale to the Swedish company Saab included a shipbuilding facility, design centre and a support operation in Sweden.[121] Although this was merely a change of

[120] Saab, "Submarines," https://www.saab.com/products/naval/submarines (accessed 16 March, 2021).
[121] Richard Scott, "Resurgam: Swedish National Security Interest Keeps Submarines to the Fore," *Jane's Navy International*, 25 June, 2019a, .

ownership, the A-26 construction and Gotland upgrades are the first major design and construction projects under this new business structure, which cannot be assumed to have retained the full German TKMS pedigree. If Canada ordered an A-26 it would likely be only the third hull of the kind to be built, and would surely incorporate variants from design, particularly if Canada opted for the extended oceanic variant.

Saab has acknowledged the risk associated with the technologically advanced A-26 design, and has leveraged the Gotland class mid-life upgrade as a test mechanism for many aspects of the A-26. The Gotland hulls were split in two to have the double Stirling AIP system installed, the same Stirling engine as the A-26, along with 20 other A-26 systems. Upgrade of the two Gotland class was completed in December 2020, and included adding a two meter hull section to incorporate the new AIP system, a diver lock-out chamber, new optronic non-hull penetrating masts, new radar and electronic warfare suites, a new snorkel, and new sonar suite among other upgrades. This complex upgrade took approximately four years for each submarine, but were done concurrently, the first boat started its refit in 2015 and returned to service in 2019, while the second hull started in 2016 and returned to service in 2020.[122] The level of upgrade in this timeframe speaks to the skill and capacity of Saab Kockum.

The A-26 Oceanic or Extended Oceanic offers a variety of capabilities that meet Canada's needs. With suitable range, comparable crewing requirements, flexible payloads to support special forces or underwater vehicles, and cutting edge technology makes the A-26 a stealthy and lethal asset for Canadian roles. The modular design boasts a high degree of maintainability and upgradability. However, the A-26 is not yet in operation, and although evolved from past proven designs, this technologically advanced platform is unproven. In any of its variants, the A-26 has

[122] Jane's, *Gotland A-19* (Online: Jane's, 2020b).

not yet been purchased by other countries, and Sweden is only building two, so there is a possibility for a Canadian variant to become a bespoke design for which it may be difficult to procure parts. Although some of this could be overcome in contracting, it is a risk that would require mitigation. The A-26 should be considered a serious contender.

**Japanese Soryu**

The Japanese Soryu class is currently operated only in Japan, with 11 of them currently in service. The Soryu design was offered to Australia as a potential replacement for the Australian Collins class, but was deemed to have too short range for Australia's requirements. Japan's submarines are designed for coastal operation around the country, and the X-bow configuration is optimized for maneouverability in shallow littorals and various straits.[123] The sophisticated Soryu design incorporates the Swedish Kockums Stirling AIP system, and the last two submarines built have incorporated lithium-ion battery technology in place of the traditional lead acid battery cells. The lithium ion battery technology offers significant energy density increase over the lead acid design, allowing the submarine to increase submerged endurance and reducing the frequency of battery recharge requirements. Lithium ion batteries are an exciting technology for submarine application, but the nature of the technology makes them susceptible to fires, or thermal runaway, an event that occurs when a sudden increase in temperature causes the batteries to suddenly release their stored energy, causing extreme temperature spikes and high levels of hydrogen gas release. Such would be catastrophic in a submarine environment. Information regarding the safeguards in Japan's two lithium ion battery Soryu class submarines is sparse, but if safety measures are found to be sufficient, this technology will have great potential in submarine

[123] Philippe Langloit, *Conventional Submarines: The Big Blue* (Online: Areion 24 News, 2016).

application. The specifications of the Soryu class are detailed in Table 7 and can be seen at Figure 5.

Table 7 - Japanese Soryu Class Specifications[124]

| | Soryu |
|---|---|
| Displacement | 2950 tonnes (surfaced)<br>4200 tonnes (submerged) |
| Length | 84 meters |
| Beam | 9.1 meters |
| Draught | 8.5 meters |
| Propulsion/Power | Diesel-Electric + Stirling AIP |
| Armament | 6 x 533 mm (21-inch) bow tubes<br>Tube launched missile capability |
| Diving Depth | 650 meters[125] |
| Speed | 20 knots (submerged)<br>12 knots (surfaced) |
| Range | 6100 nm @ 6.5kts |
| Endurance | unk |
| Crew | 65 |
| Cost | unk |


Figure 5 - Soryu Class Submarine[126]

[124] Jane's, *Soryu Class* (Online: Jane's, 2021d).
[125] Langloit, *Conventional Submarines: The Big Blue* (Online: Areion 24 News, 2016).
[126] Picture credit https://weaponsandwarfare.com/2019/12/27/ssk-soryu-class-submarines/. Accessed 18 March 2021.

The Soryu is larger than most of the designs likely to be considered for the RCN, without offering increased range or boasting any particularly unique advantages in terms of ROV or UUV operations, special forces capabilities, or extended range. The larger crew size could also be a disadvantage as Canada's submarine force is small and generating submariners takes time. The fact that the Soryu was a contender for Australia's future submarine lends credit to the design, and as such it should at least be a contender for Canada.

Comparatively, each option herein has merits and meets Canada's needs to varying degrees. Table 9 shows a comparative options analysis between the four submarine designs, applying quantitative scoring metrics to demonstrate the degree to which the design achieves the roles previously identified. The importance of design pedigree, minimal MOTS modification, maintainability, supportability and cost has been emphasized by applying a weight factor of three. Core capabilities of upgradability, range, endurance, crewing, and the inclusion of AIP in the design have been given a weight of 2. Special forces and UUV capabilities have not been weighted, as Canada could determine that these capabilities drive the overall design complexity or cost, and may be considered enhancing features that are not absolutely necessary. The maximum possible score is 108. Though the ability to communicate while submerged was identified as a requirement in *Leadmark 2050*, open source information on this is not widely available, so this capability was not considered in the analysis.[127] Likewise, the submarine design compatibility with weapons used in Canada was not included due to lack of available open source information on these specification. Each of the comparison criteria is defined in Table 8.

[127] Canada, *Leadmark 2050 - Canada in a New Maritime World* (Canada: Department of National Defence, 2016b). 39.

Table 8 - Comparison Criteria Definitions

| **Comparison Criteria** | **Definition** |
|---|---|
| Design Pedigree | Considers the maturity of the platform design, as well as the experience levels of the design/build agencies, where a score of 4 is the best. |
| Anticipated degree of MOTS modifications | The level of modification required to the design for it to meet Canadian requirements, where 4 indicates the least amount of necessary modifications. |
| Maintainability | Refers to the level of consideration for maintenance that is inherent to the design. While this analysis criteria requires deep consideration conducting a full options analysis, the analysis herein is highly subjective and based on limited information available. A score of 4 indicates the most maintainable. |
| Upgradability | Speaks to the design considerations for future upgrades. |
| Supportability | Analyzed based on the anticipated availability of spare parts, and the level of specialized skill or knowledge required for equipment upkeep. |
| Range > 7,000 NM | Designs that meet or exceed this range earn a score of 4. One point is lost for every 500 NM less than 7,000 NM. |
| Endurance > 40 days | Designs that meet or exceed this endurance earn a score of 4. One point is lost for every 5 days less than 40 days. |
| Crew ~ 50 | Crew requirements of 50 or less people earn a score of 4. One point is lost for every 5 crew members above 50. |
| AIP | Designs with inherent AIP earn a score of 4. Scores of 3 through 1 are based on the estimated level of design modification required to incorporate AIP. |
| Special forces Compatibility | Designs with inherent SF capabilities earn a score of 4. Scores of 3 through 1 are based on the estimated level of design modification required to incorporate SF capabilities. |
| UUV Compatibility | Designs with inherent UUV capabilities earn a score of 4. Scores of 3 through 1 are based on the estimated level of design modification required to incorporate UUV capabilities. |
| Cost | Relative score, where 4 is the least expensive. |

Table 9 - Submarine Comparative Options Analysis

| Comparison Criteria | Wt | German Type 214 | French Scorpene | Swedish Type A-26 | Japanese Soryu |
|---|---|---|---|---|---|
| Design Pedigree | 3 | 4 | 3 | 1 | 2 |
| Anticipated degree of MOTS modifications | 3 | 3 | 2 | 4 | 2 |
| Maintainability | 3 | 4 | 3 | 4 | 3 |
| Supportability | 3 | 4 | 3 | 2 | 2 |
| Cost | 3 | 4 | 2 | 3 | 1 |
| Upgradability | 2 | 2 | 2 | 4 | 2 |
| Range > 7000NM | 2 | 4 | 3 | 3 | 2 |
| Endurance > 40 days | 2 | 4 | 4 | 4 | 1 |
| Crew ~ 50 | 2 | 4 | 4 | 4 | 1 |
| AIP | 2 | 4 | 1 | 4 | 4 |
| Special forces Compatibility | 1 | 1 | 1 | 4 | 1 |
| UUV Compatibility | 1 | 1 | 1 | 4 | 1 |
| Weighted Score | | **95** | **69** | **88** | **52** |

The German Type 214 scored very well, with a proven design, used by multiple countries that is likely to be highly maintainable, and supportable with a reliable source of spare equipment, and boasting a well-proven AIP technology. Though the design meets the core criteria, with further analysis of the designs inherent upgradability. The Type 214 design does not incorporate special forces or UUV compatibilities, which would require further analysis for potential design modification, or adjustment in the platforms required roles.

The Swedish Type A-26 also appears to be a strong contender, although the design is not proven. While the design and build enterprise should be given some credit, as the change in ownership from Germany to Sweden did not severely diminish the reputation of the company to build submarines. The efforts to trial much of the Type A-26 equipment in the current *Gotland* class also warrants credit. However, comparatively, the Type A-26 is the least *proven* of the four

designs. The *Oceanic* meets all core capabilities with the exception of range, falling 500 nm short of the 7,000 nm requirement, but includes the special forces and UUV capabilities.

The French *Scorpene* did not meet some of the core capabilities, particularly the AIP requirement, which would require significant design modifications to incorporate, and was estimated to be a more expensive design. This scoring is comparative in nature, and does not indicate that the design would not be adequate for Canada's needs.

The Japanese design is estimated to be the most expensive, and does not meet some of the criteria. As the largest of the four designs, it still fails to meet range and endurance requirements, while requiring the largest crew. Similar to the French design, the *Soryu* would warrant further analysis and should still be considered a contender.

Each of these options show some potential to meet the capability requirements of Canada's future submarine, and would warrant further study. There are a myriad of considerations that cannot be evaluated using only open source information that would be critical to the RCN's analysis such as the ability to communicate while submerged and the compatibility of the submarines weapons systems with the weapons Canada intends to have. Gaining an understanding of the level of design modification necessary to meet Canada's essential requirements would aid in quantifying the risk that the project cost or schedule would increase, and would have to factor into such an analysis. The aim of the RCN and Canada should be to find a MOTS submarine design that meets the essential capability requirements, complies with NATO or American standards for weapons, communications, and sensors, and can be supported in Canada with minimal design modifications.

## Sustainability

Submarine sustainability refers to a multitude of factors including everything that goes into maintaining the equipment, resources available to support that maintenance, and generation of world-class submariners, with the ultimate goal of maintaining the operational availability of Canada's submarines. Canada's geography dictates that it operate a naval fleet divided between two coasts, and the ultimate goal of its submarine sustainability program is to maintain at least one submarine on each coast that is available for operations. Maintenance, resources, and personnel each need to be considered when seeking a replacement for the Victoria class, to ensure that the next flotilla can provide the RCN with the capabilities and operational availability that it needs.

### Maintenance

It is imperative to ensure that operational availability is optimized with supportable maintenance plans. Achieving this goal requires development of an optimized class plan which contains three competing factors: maintenance requirements of each submarine; number of submarines; and resources to conduct maintenance. When analyzing options for Canada's future submarines, these requirements must ensure that Canada understands the maintenance requirements, procures the right quantity of submarines, and has sufficient resources with the necessary skills to keep submarines operating in support of Canada's maritime defence.

Maintenance of the Victoria class is primarily time-based, meaning that each piece of equipment is inspected, cleaned, repaired, or replaced at set time intervals. The time-based approach to preventive maintenance allows the RCN to build maintenance windows into the submarine program. Maintenance time intervals drive maintenance cycles of submarines, and establish the frequency and length of maintenance periods that require a submarine to be

temporarily unavailable for operations. This schedule is built for the entire class of submarines in the RCN into a *class plan*, which optimizes operational availability and maintenance of the entire submarine flotilla on Canada's east and west coasts. Although this may seem logical and simple, when multiplied by hundreds of thousands of individual components with unique attributes and maintenance requirements, it becomes clear that establishing the necessary maintenance cycles is complex. Factor in that many of these systems are essential to the safety of life for submariners and the stakes increase significantly. Some of this maintenance also requires the submarines to be taken out of the water, so the class plan must also consider periodically docking each submarine at available facilities on each coast. A multitude of factors must be considered for submarines to meet the class plan, and unforeseen repair requirements further complicate matters. A hypothetical operational cycle is shown in Figure 6 for a submarine on a 12-month maintenance cycle. Minor maintenance is completed in a four-week maintenance period, while larger maintenance routines are completed during an eight-week maintenance period.

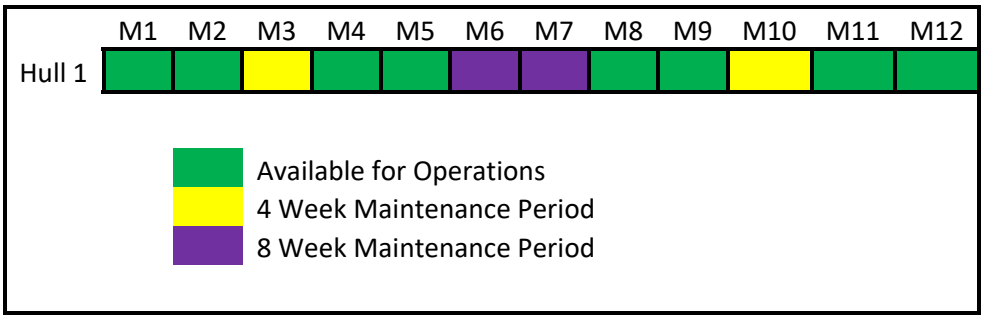



Figure 6 - Hypothetical Annual Maintenance Cycle

Figure 7 below shows how the same submarine would be maintained through multiple years, assuming that the submarine has a nine-year operational cycle and that deep maintenance periods require two years to complete. So in an ideal world, in a nine-year period, the submarine

spends two years in deep maintenance, unavailable for operations, and seven years in service with a mid-cycle docked maintenance period.

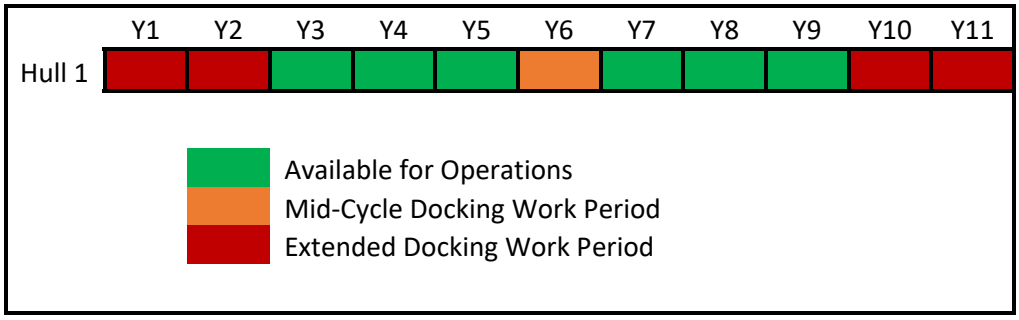



Figure 7 - Hypothetical Multi-Year Operational Cycle

Mapping the operational cycles of multiple submarines allows for development of a class plan that ensures one submarine is always available for operations on each coast. Doing so shows how many hulls are necessary to achieve operational availability goals.

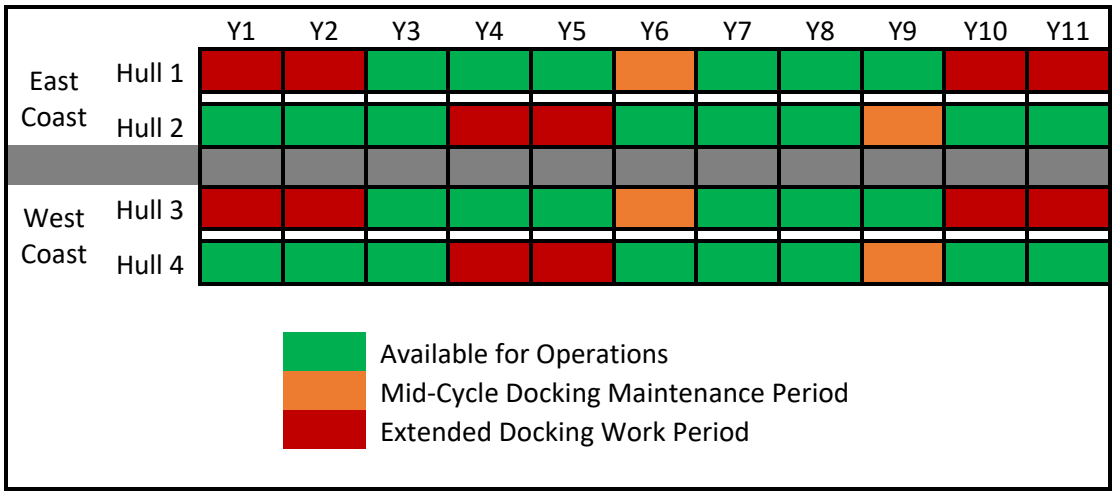
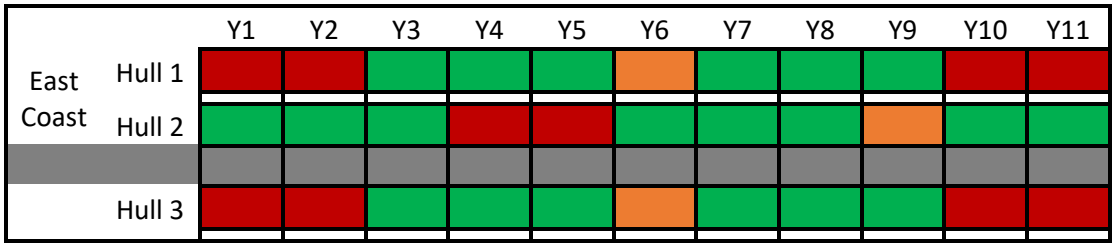



Figure 8 below shows how four hulls would be needed to maintain operational availability with the hypothetical maintenance requirements for the hypothetical submarine.



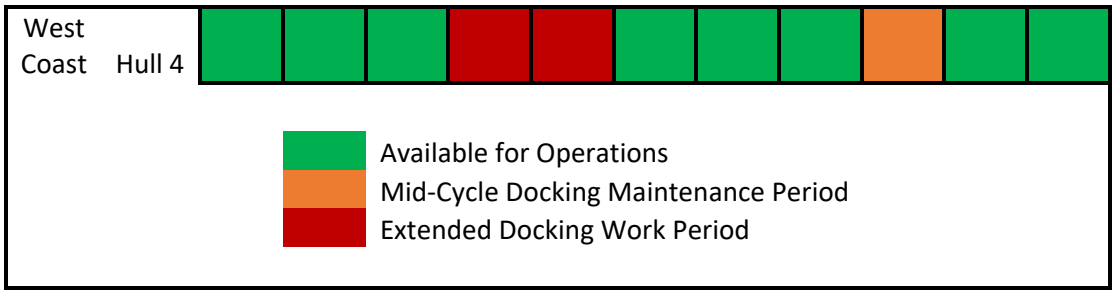



Figure 8 - Hypothetical Class Plan with Two-Year Extended Docking Work Periods

If extended work periods are lengthened by a year to accommodate increased maintenance requirements, or increased time for system upgrades or repairs, the RCN would need six hulls to maintain its desired operational availability.

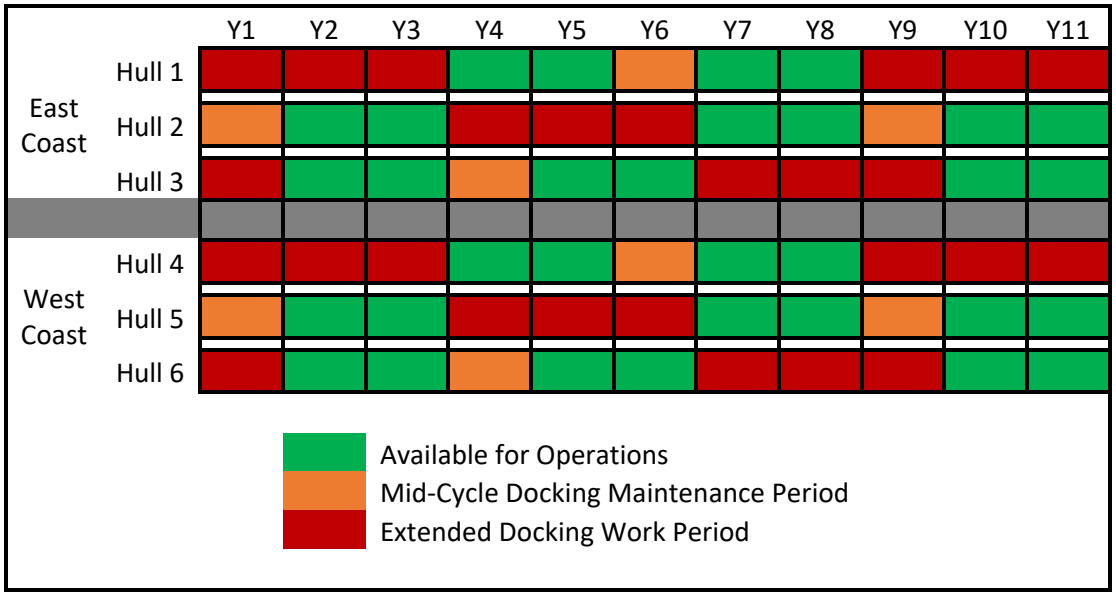



Figure 9 - Hypothetical Class Plan with Three-Year Extended Docking Work Periods

When the RCN analyzes the options for the Victoria class replacement, it must analyze the intended maintenance requirements of each design, assess the RCN's own capabilities to conduct maintenance, and determine what the operational cycle of each should look like. Doing this correctly assists in understanding the number of hulls required to maintain the operational availability that Canada requires. Since the RCN has historically operated submarines in excess

of 30 years, it must also ensure that time is allotted for system upgrades and capability insertion, as well as a capacity to address unforeseen repair requirements.

**Resources**

Second and third-line maintenance facilities and in-service support contracts need to have sufficient capacity to maintain the desired number of submarines, while also supporting other RCN assets. The Victoria class maintenance cycles are managed in-service by submarine staff and public servants in the FMFs on each coast. Third line maintenance is supported through in-service support contracts with Babcock Canada, which conducts extended docked work periods. This approach has several advantages, leveraging in-house and external expertise to maintain the submarines to a high standard.

The arrangement, in its current form, has one disadvantage that warrants reconsideration prior to signing similar contracts for the next class. Extended docked work periods are currently only conducted on the West coast, creating a single point of failure or delay, and requiring submarines based on the East coast to relocate. Conducting all EDWPs in a single facility means that only one submarine can be in extended maintenance at a time. If a submarine's maintenance period runs over-schedule, the next submarine's EDWP is delayed, which has subsequent effects for the entire class. This has been the case in the previous three EDWPs for the Victoria class, and has caused years of delay in the Victoria class plan. Since submarine maintenance is time-based, and some of the submarines systems are critical to supporting life onboard, not all of the submarine maintenance can be deferred while it awaits its turn. This results in a submarine remaining alongside in port, instead of doing operations, limiting the operational availability of the entire flotilla.

Confining third-line maintenance to a single coast means that east-based submarines need to sail or be transported to the West coast for third line maintenance, a multi-month transit that requires the submarine to be well-maintained prior to departure and causes significant wear in transit. This can cause the submarine to be in an increased state of deterioration at the beginning of the work period, resulting in additional unexpected repair requirements. There is also a potential for loss of corporate knowledge of the state of the submarine when a coastal custody transfer occurs, increasing the risk for unforeseen repair requirements which impact the cost and schedule of the maintenance period. The decision to continue conducting extended docked work periods in a single location may very well still be a valid decision, it must be taken into consideration for Canada's future submarine program.

Canada must find balance between resources to conduct maintenance and number of hulls, to mitigate the single source of failure and achieve its operational availability goals. As Canada investigates options for its next submarine, it must analyze the available support resources to ensure that the new class of submarines can be supported in maintenance requirements.

**Personnel**

The Canadian submarine service is small. Canada's submarine enterprise has 399 positions that require qualified submariners, with 338 submariners available to fill those positions. Generating qualified submariners in all required occupations takes time. Submarine training is arduous, and requires a combination of in-class learning and on-board training. Earning submarine dolphins also requires time at sea to gain exposure to submarine operations and learn to operate the various systems and machinery, after which candidates must successfully challenge a series of practical and intellectual examinations. The submarine must therefore have enough capacity to embark trainees in order to generate new submariners. Crewing requirements for

Canada's future submarine require obvious consideration, as well as any changes required to organizations that support submarines. The RCN must consider how it will attract, train, and retain its future submariners alongside procurement of a new class of submarines. Submarines cannot operate without trained crews.

The submarine service is primarily a volunteer service, attracting personnel who are seeking the challenge of arduous training and months at sea in a confined space. The shared inherent risk of sailing in a submarine creates a community with a very strong bond, a bond that is shared internationally between submariners around the world. They are the elite of the RCN. Being a submariner means being part of a special force within the RCN. Unfortunately, availability gaps and negative media coverage of the Victoria class have made it more difficult to attract and train new candidates, besides the discomfort of living and working in a confined space with stale air for extended periods of time. Shortages of qualified personnel create a heavier burden on submariners, who are required to fill multiple positions to ensure the submarines can go to sea. Increased operational tempo, and the difficulty in predicting when someone will get qualified to fill spots causes retention difficulties with personnel. Crew size, support requirements, and training factor into options for Canada's future submarine.

## CONCLUSION

Canada needs a submarine service to defend and protect its vast maritime estate, and to strengthen its standing in alliances. The changing nature of the world and technology means that Canada requires submarines into the foreseeable future. Maintaining this capability has required significant investment and effort, but is necessary for Canada's security.

Canada's submarine service evolved from a bold decision on the part of the Premier of British Columbia in the days before WWI, and the RCN has worked tirelessly ever since to maintain this capability by whatever means necessary, clearly demonstrating Canada's enduring need for submarines and the valuable capabilities that only submarines offer. The Oberon and Victoria classes have allowed Canada to gain credibility on the international stage as leading experts in ASW, and have earned Canada's position within the international submarine community. While a myriad of lessons are to be learned and improved upon from the tenure of the Victoria class, its successes stand testament to the expertise of Canada's submariners and supporting industries to continue to operate these highly complex and inherently dangerous platforms. History shows that Canada has unfailingly recognized its need for submarines for the last one hundred years, and demonstrates that Canada *can* operate and maintain a future class. What Canadians want, what industry can support, and what happens when ambition overshadows reality factor into calculations.

The submarine service must be smart in its approach to building the case for new submarines, and realistic in its pitch. Canada's two failed attempts to acquire nuclear-powered submarines should be heeded. There is no reason to believe that such a procurement would be successful today. The tenure of the Oberon class stand as the best example, a minimally modified MOTS design, built for Canada which was adequately resourced and well supported. By defining

the submarines roles and associated capabilities, Canada can explore commercially available MOTS submarine designs, requiring minimal modifications to meet Canadian needs, to secure Canada's membership in the international submarine community for decades to come and be most cost effective.

Canada's vast maritime estate and economic reliance on the security of the maritime domain demand that it retain its submarine capability. The deterrence effects of submarine operations are unmatched by any other asset in the CAF inventory. Submarines are a critical component to the security of Canada's territorial waters and coastlines, and are essential for continental security in partnership with the US. The future of warfare in the maritime domain demands submarines. As weapon and sensor technology becomes farther-reaching, submarines will be the only mechanism to deter, survey, and secure contested waters. Surface ships are increasingly becoming easy targets, while submarines offer stealth, endurance, freedom of movement, and lethality. As countries around the world seek to add submarines to military arsenals, the importance of these assets for medium-sized and middle-ranked navies continues to grow. Global power dynamics are creating maritime regions that are increasingly contested, and Canada, as a global moral leader and important member of international alliances, must be able to participate in efforts to stabilize regions and promote peace. Canada's geography stands as justification for its need for submarines to protect the homeland, while the evolution of technology and global power dynamics demands that Canada retain its submarine capability as a valued member of NATO with a respected professional armed forces.

Canada will soon find itself at an inflection point, as the Victoria class approaches end of life and Canada and the RCN must consider what will replace it. Canada should begin the process of defining the roles future submarines shall fulfill, how they will be procured and

sustained, and if the RCN can be optimized to support and operate these critical assets. A class plan, balanced between operations, maintenance, and training developed alongside the procurement plan, shall ensure the success of Canada's future submarine flotilla. In short, Canada and the RCN must learn the lessons of the past, define the intended roles, and tailor the sustainment structure to ensure operational availability.

Canada's future submarine needs to be selected against well-defined roles, based on commercially available and minimally modified MOTS designs. The next class of submarines should incorporate proven technologies, tailored and supported to meet Canada's defence needs. Several suitable options exist which meet Canada's needs, and likely more could come forward in future years. The German Type 214 is a proven design, operated by multiple nations over the last two decades, and built by an industry with a proven pedigree in the submarine business. The Swedish Type A-26 is an extremely modern design and offers some cutting edge elements that could give the design a technological advantage to meet Canada's needs for decades to come. The design is born of an industry that has a history of successful submarine design and construction, but the design itself has the distinct disadvantage that it is not yet in service. Both the German and Swedish designs are strong contenders. The French Scorpene design is also operated by multiple nations, and has been in operation for 15 years, and the French Shortfin Barracuda could offer even more possibilities. Finally the Japanese Soryu design is being actively marketed around the world, and has been in service in Japan for over a decade, with notable variations containing some interesting technologies. While the new battery technology in the two latest versions of the Soryu class might be somewhat out of reach for Canada, it demonstrates the flexibility of the design.

Whichever option Canada finally chooses to replace the Victoria class should incorporate an achievable sustainment plan for the future submarine fleet that optimizes maintenance, personnel requirements, and operational availability. Failure to build an achievable sustainment plan is as detrimental to the submarine service as the failure to procure the right submarine, and equal amounts of rigor need to go into ensuring that the RCN gets both right.

The Canadian submarine service has a hundred years of successes, hard work, investment, and lessons behind it, and now it must look to the future and determine what comes next. There is no question that submarines are a necessary component of the defence of Canada and North America, and are a vital part of Canada's contribution to its alliances. But it is also true that Canada must be scrupulous in defining the submarine's roles. The next submarine procurement must be chosen with reasonable ambition, robust sustainability planning, and realistic plans for the training and retention of its submariners. These are exciting times for the Canadian submarine service as it becomes the darling of the RCN, and if that enthusiasm can be shared with the public and polity, submarines have a bright future in Canada's national defence and sovereignty as a country.

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