

A MACDONALD-LAURIER INSTITUTE PUBLICATION

SEPTEMBER 2021

DEADLINE 2036

Assessing the requirements and options
for Canada's future submarine force

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Cover photo credits: Canadian Armed Forces (@CanadianForces), Twitter, August 7, 2021.

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Foreword

Mark Norman

It's both a pleasure and honour to write the foreword for this important research paper by Dr. Jeff Collins. As one of Canada's preeminent defence academics, Dr. Collins has written on many contemporary naval matters. In the interests of the full disclosure, I've had the privilege of working with him occasionally over the past couple of years. He has always impressed me with his passion for naval affairs, his attention to detail and his forthright presentation of compelling arguments; all of which are apparent in this most recent paper.

As the unattributed maxim goes, "you'll always have a submarine in your waters... yours, or someone else's." Canada's history with this preeminent naval weapon system of all time has been sporadic. Since the humble beginnings on the West Coast in the early days of the 20th century, Canada's submarine force has struggled with the acquisition, operation, maintenance, crewing and periodic replacement of its submarines.

The most recent chapter in the ongoing story of Canada's submarine capability has been regrettably punctuated by the near-constant criticism of the now over 30-year old *Victoria*-class. Sadly, these extremely capable platforms have become synonymous with many of the problems associated with Canada's military procurement system.

Meanwhile, beyond our myopic national horizon, and despite significant advancements in technology designed to defeat it, the modern submarine continues to evolve as the dominant global naval platform. The unprecedented international proliferation of submarines, by friends and potential foes alike, is a clear indicator of the importance maritime nations place on the ability to control their maritime estates and project credible seapower. The submarine is now, and is likely to remain, the preeminent naval platform for the remainder of this century.

The time has come for Canada to understand and embrace the important, and undeniable linkage of seapower to its national interests. Notwithstanding

the ongoing investments in both a domestic shipbuilding capacity and the recapitalization of the bulk of Canada's surface fleet, a significant component of a balanced fleet is absent from the current plan. Recent reports mentioning the impending initiation of a formal submarine replacement program are therefore an encouraging signal. This encouraging signal, however, is only the beginning.

Canada must seriously examine the need for a continued and indeed enhanced submarine capability. Were there any doubt in the preceding decades about the need for submarines, the security challenges of this "maritime" century convincingly reinforce this requirement. Regrettably, however, decisions such as whether to proceed with such an important purchase are extremely political. Notwithstanding the legitimacy of political debate in a democracy, the debate on these matters in Canada is often ill-informed, shallow, emotive and unnecessarily hyperbolic.

Dr. Collins' work should be mandatory reading for anyone interested in, or potentially commenting on, a future submarine capability for Canada. Although it is perhaps not the definitive work of its type, it is most definitely a very instructive primer. I encourage members of the media, academia, the machinery of government, elected officials, as well as potential pundits and Canadians at large to adopt a greater role in discussing the defence of Canada and its interests. Reading this paper would be a good way to start contributing responsibly to such an important discussion.

Mark Norman *is a retired Vice-Admiral of the Royal Canadian Navy.*

Executive Summary

Canada's submarine force is due for a new fleet. Constituting a quarter of the Royal Canadian Navy's (RCN) advanced warfighting capability, the four diesel-electric *Victoria* class submarines were purchased from the UK second hand in 1998 on a \$897 million lease-to-buy deal. Yet these vessels will be 50 years old by the time they are decommissioned between 2036 and 2042. Fortunately, in July 2021 the Department of National Defence revealed that a "Canadian submarine patrol project" has been sanctioned. With major defence procurement projects typically taking 15 years or more to acquire, the timing of the announcement could not come any sooner.

Despite years of persistent negative headlines, the *Victoria*-class submarine plays a key role in ensuring the RCN remains a "blue water navy" capable of defending the rules-based international order at sea, domestically and internationally. These complex platforms are frequently tasked with intelligence, surveillance, and reconnaissance missions, deterring opponents, training for the insertion and retrieval of special forces operators, building alliances, monitoring sovereign waters and Exclusive Economic Zones (EEZ), supporting ground forces ashore, and gaining national prestige. They remain the best anti-submarine warfare capability in the RCN.

Changing geopolitical currents and weapons proliferation ensure that any blue water navy will need to incorporate submarines as part of its fleet structure. Four reasons stand out:

1. Canada's ability to exert influence in its vast maritime domain will be tested as the demand for resources and northern sea access increases in the coming decades. Debate persists on China's naval capabilities and aspirations in the Arctic, for example, but there is little doubt about Russia's military interest in the region.
2. The relative decline of the US puts greater pressure on American allies to invest more in defence and step-up to meet today's security challenges through contested waters like the South China Sea.

3. The rapid build-up and aggressive posture of China's navy and large militia fleet in the South and East China Seas continue to foster a market for submarine acquisitions in the wider Indo-Pacific. Canada needs to have a submarine capability for both deployments and training with Canada's surface fleet.
4. The proliferation of comparatively inexpensive anti-access/area denial (A2/AD) weapons systems reiterates the importance of a submarine capability as the world's littoral regions (and beyond) become increasingly hostile to surface ships.

To prepare for these maritime security challenges, the RCN will need to ensure that its requirements for the Canadian submarine patrol project build upon the lessons gleaned from its own operations and those of its allies. For instance, the existing four *Victoria*-class submarines are split evenly between the Atlantic and Pacific coasts but a fleet size of six to eight is necessary to ensure the RCN has four deployment ready vessels at any time. Canada's future submarine force needs to retain significant interoperability with our US Navy counterparts. Yet we should also consider some new capabilities, including for under-ice operations, using air independent propulsion technology, and even a land strike capability.

With the US and UK out of diesel-electric submarine production, Canada lost its traditional sources of submarines. Other allies with requirements close to Canada's, like the Netherlands, operate submarines of similar vintage as the *Victoria*-class, likely foreclosing a feasible option to buy any would-be surplus submarines. This leaves three procurement options open to Ottawa and the RCN for a replacement in the Canadian submarine patrol project:

Option 1 – Domestic Build: The National Shipbuilding Strategy (NSS) is committed to the continuous, multi-decade domestic construction of federal vessels. For the submarine replacement, one or more NSS yards could build a “made in Canada” design or a Canadianized foreign design.

Option 2 – Canadianized Military-off-the-shelf (MOTS): Sweden, Spain, France, Germany, and Japan are established non-nuclear submarine producers with whom Ottawa could work in buying a Canadianized MOTS submarine. This is the most common and cost-conscious approach used by smaller allies.

Option 3 – Collaborative Build: Canada can work with an established submarine builder to split production between the two countries or enter a joint financing arrangement. This would entail a complex arrangement involving intellectual property negotiations and costs over a Canadianized design.

To avoid a capability gap and possibly lose its submarine force altogether, political and senior bureaucratic decision-makers in Ottawa will have to make a difficult call in the next two years about the kind of submarine capability the RCN and the CAF need for the next half-century.

Sommaire

La force sous-marine canadienne a besoin d'une nouvelle flotte. Le quart de la capacité avancée de combat de la Marine royale canadienne (MRC) tient aux quatre sous-marins Victoria achetés de seconde main du Royaume-Uni en 1998 dans le cadre d'un contrat de location-achat de 897 millions de dollars. Or, ces vaisseaux à moteur diesel-électrique auront 50 ans lorsqu'ils seront mis hors service entre 2036 et 2042. Heureusement, en juillet 2021, le ministère de la Défense nationale a révélé qu'un « projet canadien de sous-marins de patrouille » avait été approuvé. Comme les grands projets d'acquisition de matériel de défense s'étalent généralement sur 15 ans ou plus, l'annonce est arrivée à point nommé.

Bien que la presse se soit alarmée à leur sujet pendant des années, les vaisseaux de la classe Victoria jouent un rôle clé en veillant à ce que la MRC demeure une « flotte de haute mer » capable de défendre l'ordre international fondé sur des règles en mer, au pays et à l'étranger. Ces plates-formes complexes sont souvent chargées de missions de renseignements, de surveillance et de reconnaissance et investies de fonctions de dissuasion, d'entraînement pour l'insertion et l'extraction de forces spéciales, de construction d'alliances, de surveillance des eaux souveraines et des zones économiques exclusives et de soutien aux forces terrestres, en plus de contribuer au prestige national. Elles demeurent la meilleure capacité de combat anti-sous-marine de la MRC.

Les transformations géopolitiques et la prolifération des armes signifient que toute marine de haute mer doit intégrer des sous-marins dans sa flotte. Quatre raisons l'expliquent :

1. La capacité du Canada à exercer de l'influence dans sa vaste région maritime sera mise à l'épreuve à mesure que la demande de ressources et d'accès à l'océan Arctique augmentera au cours des prochaines décennies. Le débat persiste au sujet notamment des capacités et des aspirations navales de la Chine dans l'Arctique, mais il y a peu de doutes possibles quant à l'intérêt militaire de la Russie dans cette région.
2. Le déclin relatif des États-Unis accentue la pression sur les alliés des Américains afin qu'ils investissent davantage dans la défense et qu'ils prennent

des mesures pour régler les problèmes de sécurité actuels dans les eaux litigieuses comme la mer de Chine méridionale.

3. Le renforcement rapide et la posture combative de la marine et de la vaste flotte chinoise de miliciens dans les mers de Chine méridionale et orientale continuent de favoriser l'acquisition de sous-marins au sein de la région indopacifique élargie. Le Canada doit disposer d'une capacité sous-marine lui permettant à la fois de déployer sa flotte de surface et de l'entraîner.
4. La prolifération de systèmes d'armes « A2/AD » relativement peu coûteux mis en œuvre pour interdire l'accès ou protéger des aires non autorisées réaffirme l'importance d'une capacité sous-marine au moment où les régions littorales (et au-delà) dans le monde deviennent de plus en plus hostiles aux vaisseaux de surface.

Pour se préparer à relever ces défis en matière de sécurité maritime, la MRC devra s'assurer que ses exigences relatives au projet canadien de sous-marins de patrouille tiennent compte des leçons tirées de ses propres opérations et de celles des alliés. Par exemple, la flotte actuelle comprenant quatre sous-marins Victoria est répartie également entre les côtes de l'Atlantique et du Pacifique alors qu'une flotte de six à huit sous-marins serait nécessaire pour permettre à la MRC de disposer de quatre vaisseaux prêts à être déployés en tout temps. Le principe de l'interopérabilité avec la marine américaine doit être repris par la future force sous-marine canadienne. Toutefois, il faut également envisager de nouvelles compétences, notamment en ce qui concerne les opérations sous la glace, l'utilisation de la technologie de propulsion anaérobie et les capacités de frappes terrestres.

Comme les États-Unis et le Royaume-Uni ont cessé de produire des sous-marins à moteur diesel-électrique, le Canada a perdu ses sources traditionnelles d'approvisionnement. Par ailleurs, d'autres alliés dont les besoins sont proches de ceux du Canada, comme les Pays-Bas, exploitent des sous-marins de la même époque que le Victoria, ce qui exclut vraisemblablement toute possibilité d'achat de sous-marins excédentaires. Cela laisse trois solutions de rechange à Ottawa et à la MRC pour un renouvellement dans le cadre du projet canadien de sous-marins de patrouille :

Option 1 – Fabrication domestique : La Stratégie nationale de construction navale (SNC) vise à faire construire au pays des vaisseaux fédéraux de façon continue, sur plusieurs décennies. Pour le renouvellement des sous-marins, la SNC pourrait faire construire dans un ou plusieurs de ses chantiers navals un modèle « fabriqué au Canada » ou un modèle étranger « canadienisé ».

Option 2 – Matériel militaire canadien de série : Ottawa pourrait collaborer avec la Suède, l'Espagne, la France, l'Allemagne et le Japon, des fabricants bien établis de sous-marins non nucléaires, pour l'achat d'un sous-marin de série « canadianisé ». Il s'agit de l'approche la plus courante et la plus économique utilisée par les petits pays alliés.

Option 3 – Construction collaborative : Le Canada pourrait travailler avec un fabricant de sous-marins bien établi pour partager la construction avec un autre pays ou conclure un accord de financement conjoint. Cela nécessiterait un arrangement complexe qui supposerait la tenue de négociations sur la propriété intellectuelle et les coûts d'une conception « canadianisée ».

Pour éviter un manque de capacité ou la possible disparition pure et simple de notre force sous-marine, les décideurs politiques et les bureaucrates de haut niveau à Ottawa devront prendre une décision difficile au cours des deux prochaines années concernant le type de capacité sous-marine dont la MRC et les FAC (Forces armées canadiennes) auront besoin au cours du prochain demi-siècle.

Introduction

Canada's submarine force is due for a new fleet. Constituting a quarter of the Royal Canadian Navy's (RCN) advanced warfighting capability, the four diesel-electric *Victoria*-class submarines were purchased from the UK second hand in 1998 on a \$897 million lease-to-buy deal. These vessels will be 50 years old by the time they are decommissioned between 2036 and 2042 (Canada 2016b). Fortunately, and despite notable absences in both the Liberal government's 2017 defence policy statement and its ongoing National Shipbuilding Strategy, the first hints of a replacement effort are now underway within the Department of National Defence (DND) and the Canadian Armed Forces (CAF). In July 2021 it was revealed that a "Canadian submarine patrol project" has been sanctioned. Costs, requirements, and timelines have not yet been identified, but the timing could not happen any sooner given lengthy procurement timelines and the *Victoria* submarines' planned decommissioning period (Berthiaume 2021a).

To ensure that Canada continues to have a crewed undersea naval capability to the end of the next decade, the Trudeau government is planning to spend \$1 billion to \$5 billion for a *Victoria*-class Modernization (VCM) project and, separately, up to another \$5 billion to maintain the existing submarines. These contracts will likely be awarded by 2023 (Canada 2018a, 2018b). Notwithstanding these welcomed commitments, serious questions remain as to whether a new replacement will be ready in time for the decommissioning of the *Victoria*-class submarines. By DND's own internal analysis, it takes an average of 15 years to procure major capital defence projects in Canada.¹ The Trudeau government's own 2017 defence policy document found that 70 percent of major capital defence projects were subject to delays (Canada 2017a, 74).

Should the government fail to keep the submarine patrol project on schedule, it increases the risk of an RCN capability gap. In practical terms, if that were to happen the government of the day would be left with few feasible or politically viable options – it could either hope Canada's allies would allow the RCN to borrow submarines to train with and carry out Canada's foreign and defence policy obligations, including security in Arctic waters, or mimic the

Australians and initiate a multi-billion overhaul of the *Victoria*-class while the new submarines are under construction (Reuters 2021). Neither are promising alternatives, and both leave open the opportunity for a future government to axe the submarine force altogether.

To avoid such an outcome, this paper aims to stimulate discussion now on what capabilities and requirements the RCN needs in a future submarine fleet and reviews the navy's potential options for acquiring new submarines. This paper operates under no illusions that replacing the *Victoria*-class will be easy or cheap. A 2003 DND audit pegged the cost of four new submarines in 1998 at \$3 billion to \$5 billion (Canada 2003, 1). We can easily expect that 20-year-old estimate to be higher. However, with both growing maritime threats and changing geopolitical realities emanating from the return of rivalries among the world's great powers, the need for a timely submarine acquisition that meets Canadian requirements is more necessary today than when the *Victoria*-class were acquired 23 years ago.

Assessing Canada's submarine force

The RCN regards its submarine force as its “ultimate warfighting capability.” Any assessment of that force and the RCN's four *Victoria*-class vessels begins with tackling the years of persistent negative headlines that cloud any meaningful discussion of the force's future (Canada 2016, 39). It is true that the *Victoria*-class did not achieve their “steady state” status (i.e., having three operational boats with one in maintenance) until 2014, 16 years after the decision to acquire them (Blakeley 2015). During that time, there was a fatal fire aboard the HMCS *Chicoutimi*, a five-year refit for the HMCS *Windsor*, hull damage in 2011 from the HMCS *Corner Brook* running aground, and zero days at sea in 2019 for the entire submarine fleet due to maintenance. In 2020, HMCS *Corner Brook*'s ballast tanks ruptured during a test (Byers and Webb 2013, Nossal 2016, Brewster 2020, Berthiaume 2021b).

The classified nature of submarine operations makes it difficult to balance or add context to such headlines. These publicized troubles give the impression of wasted dollars, yet the RCN's submarine capability cost just 1.4 percent of the overall defence budget in 2019-20.² Aside from crewed spacecraft, submarines are some of the most sophisticated machines in use; no other equipment in the CAF is exposed to such an intense operational environment (Canada 2021a).

Submarines are maintenance heavy, and the importance of them being docked for lengthy periods cannot be understated. As recent submarine disasters in

the Argentine and Indonesian navies attest, there is little room for error when operating underwater (Politi and Zaveri 2018, BBC News 2021a). Even small fires, floods, and gas leaks can lead to tragedies (Bateman 2018, 18). Since 2014, the RCN adopted a new “Extended Docking Work Period” (EDWP) model that sees the submarines operating for nine years before undertaking a three-year (“9+3”) maintenance period as opposed to the previous “6+2” model. This newer approach is expected to maximize the life of the submarines to the point of their decommissioning (Canada 2016b).

Getting the *Victoria*-class submarines into Canadian service was hampered in part by hull corrosion brought about by years of salt water exposure in the UK in the 1990s. Time was also spent “Canadianizing” these vessels and ensuring their interoperability with our allies so they could operate seamlessly with the US Navy (USN) and other RCN surface vessels. As the *Victoria*-class are an “orphan class” with no other copies in service anywhere, the RCN had to recreate the supply chain to maintain and sustain the vessels (Canada 2005, 33; Canada 2003, 4; Nossal 2016, 58). Canada is hardly alone among allies in dealing with such problems. In 2017, all six of Germany’s submarines were out of commission after the one operational submarine was involved in an accident. Germany, one of the world’s largest exporters of submarines, did not have enough spare parts available for timely repairs of its own vessels (Sprenger 2017).

“ *The RCN’s submarine capability cost just 1.4 percent of the overall defence budget in 2019-20.* ”

The lingering legacy of unrestricted submarine warfare from the First and Second World Wars also muddies the submarine force’s public image. Popular historical references of the submarine as a purely offensive weapon targeting hapless merchant shipping can be hard to fight against, especially when prominent voices like former Liberal Foreign Affairs Minister Lloyd Axworthy label submarines “un-Canadian” (cited in Greenfield 2015). Yet this image is outdated. Submarines today rarely engage in combat at sea (Lautenschläger 1986-87, 98). There have only been three publicly known sinkings of ships by submarines in conflict since the end of the Second World War.³ The modern diesel-electric or air independent propulsion (AIP) powered submarine like the *Victoria*-class and their *Oberon* predecessors are a much more versatile piece of equipment than their Second World War-era incarnations.

The *Victoria*-class are complex platforms frequently tasked with intelligence, surveillance, and reconnaissance (ISR) missions, deterring opponents, train-

ing for the insertion and retrieval of special forces operators, building alliances, monitoring sovereign waters and Exclusive Economic Zones (EEZs), supporting ground forces ashore, and gaining national prestige. Their *Oberon*-class predecessors were also tasked with multiple roles during the latter years of the Cold War.⁴ Given their mix of underwater, hull mounted, and towed long- and medium-range sonars, submarines offer the best anti-submarine warfare (ASW) capability in any navy (Naval Technology Undated). It is no surprise that the goal of any modern submarine is to remain undetected as much as possible (Lautenschläger 1986-87, 98, 109).

In 2018, Liberal Defence Minister Harjit Sajjan captured the importance of these capabilities when he stated, “No other platform in the Canadian Armed Forces can do what a submarine can do. No other platform has the stealth, the intelligence-gathering, surveillance and reconnaissance capability and the deterrence to potential adversaries that a sub does” (Pugliese 2018).

With a submerged displacement of 2400 tonnes, Canada’s diesel-electric *Victoria*-class are not only smaller than nuclear submarines such as the American *Virginia*-class (7300 tonnes) or British *Astute*-class (7400 tonnes), but also quieter. Nuclear submarines cannot shut off their reactors and require deeper, colder water to remain cool, thus limiting their ability to operate in the world’s littoral (i.e., near shore) regions. In contrast, non-nuclear submarines like the *Victoria*-class can get close to harbours and other busy maritime traffic areas and monitor cell phone transmissions or high frequency, very high frequency, and ultra-high frequency signals (Kraska 2015, 191). These same attributes can also be used for inserting or retrieving special forces operators, if needed.

Being able to conduct up to eight-week-long patrols in any weather condition, the *Victoria*-class submarines deploy extensively on domestic and global intelligence, surveillance, and reconnaissance training and monitoring activities, including in support of RCN and allied constabulary duties (Canada 2019). The submarines were sent regularly to the Caribbean and eastern Pacific in concert with the US on anti-drug monitoring and interdiction efforts (Pugliese 2013). The submarines also work with other federal departments like the Fisheries and Oceans Canada on fisheries patrols or with the Royal Canadian Mounted Police (RCMP) on anti-narcotic operations and to assert Canadian sovereignty (Maloney 1998).

Although none of Canada’s submarines operate under Arctic ice given the high level of risk in that environment for diesel-electric submarines (which must regularly resurface to recharge their batteries and lack adequate ice penetrating hull designs), they do operate in the near Arctic during summer months, undertaking covert surveillance missions and training exercises (Jeferd-Moore 2018). The upcoming *Victoria*-class Modernization (VCM) project is expected to enhance the *Victoria*-class near-Arctic operating capabilities

and the upgrades will introduce a new sonar, which will allow for better ice-berg detection (Coyne 2021).

In a testament to the value of having a long-range undersea capability, in 2017-18 the submarine force completed two of its most ambitious missions yet known: the first Canadian submarine deployment to Japan in 50 years with the HMCS *Chicoutimi*'s 197-day sail to the Far East and the HMCS *Windsor*'s 133-day NATO strategic anti-submarine warfare deployment in the eastern Atlantic and Mediterranean, performing counterterrorism and maritime security monitoring. There are even hints that HMCS *Chicoutimi*'s deployment involved the monitoring of UN sanctions against North Korea, something to which Ottawa eventually mused publicly about committing submarines (Canada 2021b, Sevunts 2018, Brewster 2019).



Submarines remain unique among CAF assets for their deterrence impact.

Submarines remain unique among CAF assets for their deterrence impact. The actual or inferred presence of a submarine, with its endurance, stealth, and modern weapon systems like the *Victoria*'s MK-48 torpedoes, can alter an opponent's strategic calculus (Canada 2016, 39). In this sense, the submarine is a "classic force multiplier" that requires a "disproportionate response from an adversary" (Bateman 2018, 15-16). The British demonstrated this bluntly in the 1982 Falklands War when the submarine HMS *Conqueror* sank an Argentine cruiser, which then led to the complete retreat of the Argentine surface fleet, stranding the garrison of 9000 on the islands to their fate. The Royal Navy likewise struggled to track and attack an Argentine diesel-electric submarine in the war (Burns 2012, 212, 440-41; Hastings and Jenkins 1983, 147, 323).

Canada has also experienced the deterrent power of its submarines, albeit during one its constabulary operations. During the 1995 "Turbot War" with Spain that centred on a dispute over overfishing, the mere publication of a "notice of intention" indicating the presence of an *Oberon*-class submarine played a pivotal role in resolving the tension between Madrid and Ottawa (Maloney 1998). Modern non-nuclear submarines have equally demonstrated their deterrence and warfighting potential in training exercises. In 2005, Sweden's AIP-powered 1600 tonne HSwMS *Gotland*, capable of remaining submerged for up to two weeks by operating on an innovative battery power system using liquid oxygen, managed to evade and "sink" a US *Nimitz*-class nuclear-powered aircraft carrier during a war game (Roblin 2021).

The advent of unmanned underwater vehicles (UUVs) in recent years has spurred debate in academic and naval policy circles as to the future of crewed submarines. Tellingly though, the world's major navies envision UUVs as complementing crewed submarine operations, not displacing them. The Pentagon's plans for up to 50 large "Orca" UUVs over the coming two decades is to use them to perform niche, high-risk missions like mine warfare and free up the existing crewed submarines for other ISR, fleet protection, or missile-strike activities (Larter 2020). UUV technology equally remains limited by battery life (although the experimental Russian nuclear powered "Poseidon" could represent a game changer) and issues with communication links due to the density of sea water (Mishra 2019).

Finally, Canada's submarines serve as an important tool in defence diplomacy, intelligence collecting, and alliance building. Being in the "sub club" allows Canada to participate in the global Water Space Management (WSM) regime. The WSM gives Ottawa access to classified information on allied submarine operations that are key to avoiding mutual interference at sea (Canada 2017b). Canada's 2017 defence white paper, *Strong, Secure, Engaged*, sees the *Victoria*-class as "a key element of the system of systems approach to maritime domain awareness" and a component of the CAF's joint ISR network (Canada 2017a, 65). Given the shared continental alliance and focus on interoperability, the RCN integrates officers with USN submarine staff. The USN itself routinely seeks opportunities to train against the diesel-powered *Victoria*-class, given the prevalence of non-nuclear submarines in the world and the fact that the USN is an all-nuclear submarine fleet (Mitchell 2013, 18-19).

With such a small community of allied diesel-electric/AIP submarine operators, the RCN maintains close ties with the Netherlands, Norway, and Australia. Canadian submarine officers routinely enroll in the Dutch submarine command course (informally known as "Perisher") and, separately, maintain an ongoing exchange with the Royal Australian Navy (Ferguson 2014, 329). Due to increased trade and security ties between Canada and the Indo-Pacific, the RCN is also exploring opportunities to ensure interoperability with Japan's submarines and surface ships (Sevunts 2021).

Looking to Canada's submarine past

Simply put, the history of past Canadian submarine acquisitions is one of luck and timing: relatively cheap and often surplus submarines conspired with tight budgets and just enough political interest to justify purchases. This is not a recipe that can be replicated today. Take, for example, Canada's first submarines, acquired at the beginning of the First World War not by Ottawa

but by the Premier of British Columbia who feared German Pacific naval raiders. Those boats, *CC1* and *CC2*, only became available because the Chilean government fell into arrears with their Seattle builder. After the war ended and the postwar cutbacks of the 1920s kicked in, those boats and their successors, *CH14* and *CH15*, were disposed of, thus ending the first iteration of the RCN's submarine force (Ferguson 2014, 132-136).

It took the Second World War and the devastating impact of Nazi *untersee-boots* on Canadian naval and merchant shipping to reignite the importance of having a submarine force to not only train the RCN in anti-submarine warfare but also incorporate a critical warfighting capability within the CAF. That experience mixed with Canada's Cold War NATO duty to help secure the North Atlantic sea corridors became the impetus for restarting the RCN's submarine force, a process that would take nearly two decades to bring to fruition. With both the US and UK still operating diesel-electric submarines amid a turn to nuclear propulsion, Canada could still count on both allies to obtain the necessary institutional knowledge and experience needed to regenerate its own submarine capacity. Canadian submariners were assigned to these allied navies while the British stationed their 6th Submarine Squadron in Halifax through the 1950s and early 1960s (Ferguson 2014, 262-265).



The history of past Canadian submarine acquisitions is one of luck and timing.

The second iteration of Canada's submarine force began with second-hand ex-US Navy boats from the Second World War: HMCS *Grilse*, introduced in 1961, and HMCS *Rainbow*, acquired in 1968 in place of the *Grilse*. Based near Victoria, the *Rainbow* was cut in 1974 over costs. A Canadian Pacific submarine presence only returned with the *Victoria*-class ships 30 years later. In between the US acquisitions, Canada bought its first and only new submarines – three British-made *Oberon*-class boats. Costs and political queasiness quashed a planned nuclear submarine buy leaving the *Oberons* as the sole remaining cost-effective (i.e., cheaper) option for Ottawa (Ferguson 2014, 270-277). Unlike the current *Victoria*-class, however, the Canadian *Oberons* had the benefit of being part of a class of 27 *Oberons* in service with six navies including the UK and Australia. This avoided the problem of operating an orphan class of vessels, allowing the RCN to leverage the experience and supply chain of its allies (Nossal 2016, 55-58).

Initially only used as ASW training tools (“clockwork mice”) for the RCN and the Royal Canadian Air Force (RCAF), the *Oberons* became combat capable in the 1980s following NATO pressure and an extensive refit that introduced US combat management systems, sonars, and MK-48 torpedoes (Milner 2010, 232; Tracy 2012, 174-175). An attempt by the Mulroney government to buy a dozen nuclear submarines in 1987-89 ran into the same issues of cost and domestic political unease (plus a lack of offset opportunities) as 20 years before, except this time the geopolitical rationale for the then estimated \$10 billion (1989 dollars) purchase collapsed with the end of the Cold War and the Soviet Union (Lajeunesse 2007-2008, 74-82).

Once the nuclear plan failed, the RCN was left with few options. The *Oberon*-class were due to be replaced by 2000 yet the defence budget was cut significantly in the 1990s as part of an effort to reign in the country’s spiralling deficit (Nossal 2016, 56). As luck would have it, in 1994 the UK declared that its submarine fleet would go all nuclear, freeing up four recently built *Upholder*-class diesel-electric submarines for purchase. Had the *Upholders* not been available, Canada likely would have followed the route of fellow ally Denmark and lost its submarine capability altogether. It took four years, a concerted pitch from the British, pressure from two US Secretaries of Defense, and a stable federal balance sheet to finally make it viable for the Chrétien government to approve the eventual \$897 million lease-to-buy arrangement with the renamed *Victoria*-class in 1998 (Craven 2007, 23).

Dangerous tides: The case for renewal

Building a navy, as the RCN’s own 2016 *Leadmark 2050* strategy notes, is a “series of 40 to 50 year investments” (Canada 2016, x). A key challenge in building a navy is determining what specific capabilities the country will require decades into the future. Enter operational and geopolitical trends, both of which point to the continuing need for crewed submarine capabilities. Regarding the former, the post-Cold War RCN continues to take on a much wider breadth of operations than its North Atlantic, Soviet-focused predecessor. Outside of domestic sovereignty and “whole-of-government” missions (e.g., anti-drug), the RCN completed more than 110 international missions between 2001 and 2017, covering the entire spectrum of operations from combat and deterrence to constabulary and humanitarian assistance and disaster relief (HADR) (See Table 1) (Canada 2017c, 4).

Leadmark 2050 makes it clear that the purpose of the RCN is to defend “the global system at sea and from the sea, both at home and abroad.” To do this, the navy requires a fleet “of sufficient size” capable of continuously deploying

across Canada’s three oceans and responding to major international crises (Canada 2016, iv-v). *Strong, Secure, Engaged* endorsed the RCN’s goal of being a globally deployable “blue water navy” and the framework at the heart of this goal is the naval task group (NTG). The NTG is centred around three to four combatant vessels, including submarines, and a support ship, able to respond and sustain a global operation (Canada 2017a, 34). British maritime strategy expert Geoffrey Till argues that the NTG formation makes the most of Canada’s defence budget constraints, middle power ranking, and fleet size by offering Ottawa a balanced mix of naval capabilities to meet a range of missions like those identified above (Till 2018, 153).

TABLE 1: POST-COLD WAR RCN INTERNATIONAL MISSION TYPES

Type	Example
Combat	<i>Op Mobile</i> - Defence of Misrata, Libya, against pro-regime forces in small boats (2011)
Deterrence	<i>Op Reassurance</i> - supporting NATO deterrence against Russia in Central/Eastern Europe (ongoing)
Sanctions enforcement	<i>Op Neon</i> - UN sanctions enforcement against North Korea (ongoing)
Constabulary	<i>Op Caribe</i> - anti-narcotics/smuggling in Caribbean Sea/Eastern Pacific (ongoing)
	<i>Op Artemis</i> - counter-terrorism/counter-piracy/maritime security operations in Middle Eastern/East African waters (ongoing)
Humanitarian assistance and disaster relief	<i>Op Renaissance Irma Maria</i> - Caribbean hurricane relief (2017) <i>HMCS Vancouver</i> responded to the New Zealand earthquake (2016)
Defence diplomacy	<i>Op Projection</i> - Global maritime training, capacity building, and alliance cooperation (ongoing)

Source: Canada 2021c

Changing geopolitical currents and weapons proliferation ensure that any true blue water navy, especially one that aspires to deploy one to two NTGs, will need to incorporate submarines as part of its fleet structure.⁵ Four reasons for this stand out. First, with the world’s longest coastline, second largest continental shelf, fifth largest exclusive economic zone (EEZ), and contested Arctic claims, Canada’s ability to exert influence in its own maritime domain will be tested as the demand for resources and northern sea access increases in the coming decades. The *Victoria*-class Modernization project’s promise

to upgrade the existing submarines' near-Arctic operating capabilities in conjunction with the soon-to-open Nanisivik Naval Facility (capable of refuelling both the RCN's surface and submarine fleets) in Nunavut, point to the importance of having a strategic naval asset like a submarine in the Arctic region to perform ISR activities even if it's not capable of safely going under Arctic ice (Canada 2020b, 15).

Debate persists on the ability or interest of China's Peoples Liberation Army's Navy (PLAN), to operate nuclear submarines and other naval assets in the Arctic, but there is little doubt about Russia's military interest in the region (Lajeunesse and Choi 2020). Refurbished Soviet bases, armed icebreakers with anti-ship missiles, troop deployments, cruise missile testing, and Tu-95 bomber overflights all aim to leverage future economic activity in the Arctic and dissuade Western militaries, especially navies (BBC News 2021b, Kramer 2021). Russian naval activity extends to the North Atlantic too. The Kremlin's submarine fleet is arguably the most potent component of its conventional military forces and the main recipient of upgrade money which has otherwise largely gone to the army. Russia's submarines are now active in the North Atlantic and Arctic in numbers not seen since the end of the Cold War. This puts more pressure on Ottawa to monitor the waters in its own backyard, especially given Canada's Five Eyes and NATO intelligence sharing arrangements (Thompson 2021).

“ The Kremlin's submarine fleet is arguably the most potent component of its conventional military forces.

Canada's experience monitoring and deterring overfishing in the North Atlantic in the 1990s illustrates both the utility of submarines performing lower-end operations and the demand for Canada's maritime sea resources. Sea-based minerals, protein, and petroleum continue to be in demand in a food- and energy-hungry world. Monitoring and repelling breaches of Canada's EEZ and continental shelf will require the full remit of CAF resources, including helicopters, satellites, ships, and submarines working in tandem with other federal agencies to ensure that Canada's interests are maintained.

Second, we are currently witnessing the relative decline of the United States – the longstanding guarantor of the postwar 1945 rules-based international order – due to competing internal and external pressures including fleet overstretch, divided domestic institutions, quasi-isolationism, trade protectionism, and the return of great power rivalries for the first time in 80 years. That reality puts greater pressure on American allies to invest more in de-

fence and to help meet today's security challenges in contested waters like the South China Sea (United States, Navy Office of Information 2021). This remains one of the few bipartisan areas of agreement in Washington and transcends the Obama, Trump, and Biden administrations (Mehta 2021).

With China and Russia building up their respective nuclear and non-nuclear submarine fleets, it will become harder for Canada to ignore the need to maintain its submarine capability, even if for just ASW training and littoral ISR missions. The idea that Canada could return to its 1950s past of relying on US or UK submarines to undertake these missions on our behalf is myopic. Notably, some allies are already taking the hint. This year, the UK dispatched its first carrier strike force, including an *Astute*-class nuclear attack submarine, to the Indo-Pacific in support of freedom of navigation in the South China Sea and supporting regional allies (Chan 2021). In this vein, Australia is also investing in new submarines, as are Germany, Spain, Norway, and the Netherlands.⁶ Indeed, Australia has recently signed a new security partnership with the US and UK that will provide Canberra with nuclear submarine technology in lieu of its previous plans for diesel-electric submarines.



Of the world's estimated 43 states with submarines, 13 are Indo-Pacific coastal states.

Third, the rapid build-up and aggressive posture of the PLAN and Beijing's large militia fleet in the South and East China Seas continues to foster a market for submarine acquisitions in the wider Indo-Pacific, now home to most of the world's submarines. Of the world's estimated 43 states with submarines, 13 are Indo-Pacific coastal states. Not counting the small and coastal ranging midget submarines that Pakistan, Vietnam, Iran, or North Korea use, the region is home to 153 of the world's 407 known active submarines. That number is expected to grow to up to 300 by 2030 (Donnellan 2021).

Key regional players like Vietnam, Malaysia, Australia, Singapore, Taiwan, and India seek to counter the PLAN's superiority in aircraft carriers (Beijing's so-called "strategic fist"), submarines, and growing number of sophisticated surface combatants and amphibious ships like the Type-055 and Type-075, respectively, with the asymmetric advantages in stealth and deterrence found in modern diesel-electric and AIP submarines (Medcalf 2020, 201-202; Lendon 2021). The best ASW tool, it is said, is another submarine. And in a region like the Indo-Pacific – where nationalist tensions are rife, a regional NATO-like security architecture absent, and where Canada sees increasing economic and political ties – having a submarine capability for both deployments and train-

ing Canada's surface fleet will be less a luxury and more of a requirement.

Finally, the proliferation of comparatively inexpensive anti-access/area denial (A2/AD) weapons systems, and now aerial drones, reiterate the importance of a submarine capability as the world's littoral regions (and beyond) become increasingly hostile to surface ships. Anti-ship ballistic and cruise missiles, like China's DF-21D and DF-26 or Russia's *Bastion/Kalibr* are becoming "more intelligent, faster, longer-range and with heavier payloads," representing "a new level of threat to surface ships" even when not operating too close to shore (Till 2018, 163). These are not hypothetical threats. China's man-made islands in the South China Sea (ruled illegal in 2016 by The Hague) feature anti-ship and anti-air missiles like the YJ-12B, which aim to challenge the US carrier battle groups in which Canadian frigates operate (Geaney 2020; Stashwick 2018). Such missiles could potentially disrupt global trade in key maritime transit points (e.g., Strait of Hormuz, Strait of Malacca) where much of the 80 percent of all global goods, including 20 percent of the goods Canada trades outside of North America, move by ship annually (UNCTAD 2020; Expert Panel on the Social and Economic Value of Marine Shipping to Canada 2017).

Wars in the 1980s over the Falkland Islands and in the Persian Gulf foreshadowed the devastating impact of anti-ship missiles on naval and commercial shipping. More than 80 states now possess such missiles, with 22 building their own, of which 17 are using imported designs (Fahrenkopf 2016). The ease and danger of such weapons in the hands of non-state actors was amply demonstrated in 2006 when Hezbollah fired an Iranian-made variant of the Chinese Silkworm missile against an Israeli corvette, causing extensive damage and killing four of its crew (Mazzetti and Shanker 2006). China has since reputedly supplied its C-802A anti-ship missiles to Venezuela (Sutton 2020). In such an environment, the ability of submarines like Canada's Victoria-class to perform ISR missions, launch missile strikes, and insert and retrieve special forces operators remains a vital function for the RCN and allied navies.

Future submarine requirements

To prepare for these maritime security challenges, the RCN will need to ensure that its requirements for the Canadian submarine patrol project build upon the lessons gleaned from its own operations and those of its allies. Eight requirements stand out:

- **Arctic operations:** The RCN's own current strategy emphasises the need for a replacement submarine to incorporate "the unique requirements and design elements associated with operations under ice" (Canada 2016, 50). Although the VCM will improve the *Victoria*-class's ability to oper-

ate in near-Arctic ice, Canada remains without the crucial under-ice submarine capability to help complement the planned underwater sensors, modernized CP-140 patrol aircraft, and *Harry DeWolff*-class Arctic and offshore patrol ships now entering service (Canada 2017e). Under-ice capabilities are typically associated with nuclear submarines but the combination of advances in AIP technology (see below) and hull strengthening for ice penetration provides an opportunity for short duration under-ice missions.

- **Crewing:** Recruiting and retaining submariners is a problem across many navies. Being underwater for days and weeks at a time, with little to no contact with families at home, in often cramped, austere conditions remain a personnel barrier. Australia, the UK, the Netherlands, and Canada have all encountered similar staffing problems (Andersson 2015, 22). The VCM, with its promises of improving the habitability and deployment conditions on the *Victoria*-class, shows that the RCN recognizes the need to balance operational security and stealth with work-life balance expectations – something even former Canadian submariners have called for (Joilin 2015, 20). The absence of such considerations has real world operational impacts by limiting the deployments of the submarine fleet.
- **Design:** The trend in recent Canadian major defence capital projects like the \$19 billion Future Fighter Capability or \$70 billion-plus Canadian Surface Combatant is to work with an existing military-off-the-shelf (MOTS) or evolved MOTS design. For a submarine replacement, using a design like Sweden’s Expeditionary Submarine proposal under consideration in the Dutch *Walrus*-class replacement project or Spain’s *S-80 Plus*, comes with the benefits of avoiding an orphan class and cementing relations with an established manufacturer – important considerations for sourcing spare parts, maintaining the vessels, and undertaking future upgrades over the life of the fleet. Yet, experienced with its now cancelled 5000 tonne diesel-electric *Attack*-class submarine project (based on the French nuclear *Shortfin Barracuda*-class), overly ambitious requirements meshing with intellectual property negotiations represent a formidable barrier, so early industry participation will be critical (Stuart 2021).
- **Fleet Size:** Successive white papers and parliamentary studies (see Table 2) have called for a larger submarine fleet ranging anywhere from six to a dozen submarines. The existing four *Victoria*-class submarines are split evenly between the Atlantic and Pacific coasts but under the navy’s Extended Docking Work Period framework only two are available at a higher state of readiness at a given time while one submarine is in transition, and one is in maintenance. This fleet availability excludes the impact of unforeseen accidents and mechanical problems. A fleet size of six to eight submarines shared equally between the two coasts would allow the RCN to have four vessels deployment-ready at all times.

TABLE 2: GOVERNMENT AND PARLIAMENTARY FLEET SIZE RECOMMENDATIONS

<i>White Paper on Defence</i> (1964)	Explore the possibility of building two to three nuclear-powered submarines.
<i>Challenge and Commitment:</i>	
<i>A Defence Policy for Canada</i> (1987)	Acquire a fleet of 10-12 nuclear-powered submarines.
<i>Canadian Defence Policy</i> (1992)	Replace three Oberon-class submarines with up to 6 “modern conventional submarines”
<i>White Paper on Defence</i> (1994)	Acquire three to six “modern diesel electric submarines”

Sources: Canada 1964, 23; Canada 1987, 53; Canada 1992, 22; Canada 1994, 34; Canada 2017f, xi, 65.

- Interoperability:** Canada is the only country with a bilateral commitment to defend the United States. The last 80 years of Canada-US cooperation and collaboration in continental and international security has made the CAF one of the most interoperable allied militaries for the Americans anywhere. Any future submarines must include combat management systems, weapons, sensors, and communications technologies that are interoperable with those of our US Navy counterparts. As Canada experienced with both the *Oberon* and *Victoria* submarines, buying direct from even a close ally like the UK leads to time-consuming and costly Canadianization programs. The adoption of the British Type-26 design for the Canadian Surface Combatant project is a useful template for building US systems into a non-US design.
- Strike Weapons:** Canada’s submarine force is unique among close allies for not having any anti-surface or land strike weapons. In fact, a Harpoon missile capability was removed over cost concerns during the Canadianization program of the *Victoria*-class 20 years ago (Mitchell 2014, 3). Littoral missions in the post-Cold War illustrate the importance of such a land strike capability both for “first strike” situations, but also to further enable joint operations with air and ground forces. In the wars against Serbia, Iraq, and Libya, the US and UK showed the power of submarines working as cruise missile platforms (Patton 2005, 132-139). Russia has similarly used some of its submarines in this role in Syria (BBC News 2017b). Navies like Australia and the Netherlands are already incorporating land strike missiles in their future submarine programs too – something being done in the Canadian Surface Combatant project with the Tomahawk cruise missile (Naval News 2021).
- Propulsion:** The domestic political blowback, lengthy intellectually

property negotiations, production costs, and need for expansive support infrastructure likely rule out Canada's purchasing nuclear-powered submarines. The Canadian submarine force has only used diesel-electric submarines and although quieter than nuclear, diesel-electric submarines are limited in their ability to perform under-ice Arctic operations given the need to surface periodically to "snorkel" and recharge their batteries by running the engines.

AIP systems, however, show the most promise for Canada and were even recommended in a 2017 Senate study (see Table 2). Initially found in smaller submarines, like Germany's 1800 tonne Type-212, which are designed to patrol littoral zones, advances in AIP technology have seen its incorporation into large patrol submarines like Japan's 4600 tonne *Soryu*-class, which uses the Swedish Kockums closed-circuit diesel generator powered by chemical fuel cells, or Spain's 2900 tonne *S-80* Plus-class, which uses bioethanol fuel cells, which points to promising technology for the RCN (Mizokami 2021; Sutton 2021). Limitations exist on speed and overall endurance because of fuel storage space, but the ability of some types of AIP submarines to remain submerged for up to two weeks at a time, like the Type-212, offers a potential under-ice Arctic capability.⁸

- **Range:** A vast maritime domain and sparsely populated coastline with little in the way of support infrastructure requires Canadian submarines to operate on long-range patrols far from shore support. The 100-plus day missions in 2017-18 have set the bar for the type of long-range, high endurance operations the RCN will and can undertake internationally. In practical terms, this means Canada is one of a handful of countries operating large, non-nuclear submarines (also including Australia and Japan) and limits the pool of designs to those that either have existing large, long-range, non-nuclear patrol submarines (Spain and Japan) or that have modified smaller submarine designs to meet such a requirement (Sweden and Germany).

Build options

With the US and UK no longer producing diesel-electric submarines, Canada has lost its traditional sources of submarines. Other allies with requirements close to Canada's, like the Netherlands, operate submarines of similar vintage as the *Victoria*-class, likely foreclosing a feasible option to buy any would-be surplus submarines. Buying the four used *Walrus*-class in the 2030s, for example, would require an extensive Canadianization and leave the RCN with yet another (aging) orphan class of submarine – from a defunct producer.

If Canada decides to forgo a decision to replace its submarines, it could

rebuild the *Victoria*-class vessels to extend the life of the submarine force by another decade or two. Australia has been pursuing this option. Faced with delays in its *Attack*-class replacement project, Canberra committed in 2021 to a \$5.5 billion rebuild of its six *Collins*-class submarines. This decision would extend the vessels' lives by up to 20 years, avoiding a capability gap in the early 2050s as the new submarines enter service (Kadib 2021). Such an option would have in effect created a new submarine capability. Of course, the recently announced agreement between Australia, the UK, and the US may mean a possible change to this plan. However, if Canada takes Australia's life extension route, it will still be left with fewer submarines than required and, unlike Australia, bear the cost of undertaking such a project without the experience and institutional knowledge that the Royal Australian Navy earned from building the *Collins* boats domestically.

This leaves three procurement options open to Ottawa and the RCN for replacing the Canadian submarine patrol vessels:

Option 1 – Build the submarines domestically under the National Shipbuilding Strategy. Canada's National Shipbuilding Strategy (NSS) is committed to the continuous, multi-decade domestic construction of federal vessels. Large vessels (i.e., over 1000 tonnes) are to be built at one of three NSS yards. For the submarine replacement, one or more NSS yards could build a "made in Canada" design or Canadianize a foreign design akin to Australia's adaptation of the Swedish *Västergötland* for the *Collins*-class. As a country with no recent history of modern naval submarine production, Canada will face the hurdles of building up a new industrial capability and formatting a foreign design to work for Canadian shipyards while those shipyards are building other NSS projects. The upside is that Canada would acquire the institutional knowledge and expertise necessary for future upgrades, maintenance, and spare part production.

Option 2 – Canadianized MOTS. Sweden, Spain, France, Germany, and Japan are established non-nuclear submarine producers with whom Ottawa could work in buying a Canadianized military-off-the-shelf (MOTS) submarine. This is the most common and cost-conscious approach that smaller allies use, but if Canada were to take this route it would be politically contentious and lead to strife in the industry (especially from the NSS yards). In lieu of overseas construction (and with it jobs) a Canadian government would have to ensure that an equitable percentage in offsets would return to Canada under the existing federal Industrial and Technological Benefits policy (ITB). The experience of the soon-to-be awarded (in 2022) \$19 billion Future Fighter Capability contract for 88 fighter jets could help provide insight into a big budget, complex MOTS defence procurement (Canada 2021d).

Option 3 – Collaborative build. Canada could work with an established submarine builder to split production between the two countries or enter a joint financing arrangement. Australia and New Zealand collaboratively built the *ANZAC*-class frigates in the 1990s (Collins 2015, 30-32). This year Norway signed a deal with Germany to build six Type-212 AIP common design submarines and new Naval Strike Missiles. Four will replace Norway’s six *Ula*-class submarines while Germany will retain two (Norway 2021). To be part of a collaborative build, Canada would have to enter a complex arrangement with a viable partner that would involve intellectual property negotiations and the cost of a Canadianized design, but the country’s domestic industry would retain some institutional knowledge and expertise and Canada could reduce the likelihood of owning an orphan class.

Conclusion

To avoid a capability gap and possibly lose its submarine force altogether, political and senior bureaucratic decision-makers in Ottawa will have to make a difficult call in the next two years about the kind of submarine capability the RCN and the CAF need for the next half-century.

The geopolitical changes and maritime security threats Canada and its allies face are real. The days of the early post-Cold War 1990s when Canada was contemplating whether it even needed a submarine fleet are over. It is tempting to think UUVs could replace the *Victoria*-class, but all indications point to a future where UUVs work in tandem with crewed submarines. Akin to their air forces, none of the world’s major or key mid-sized navies are opting to scrap their crewed submarines for drones. As such, it is with hope that the assessments, requirements, and options produced in this paper facilitate a wider Canadian defence and foreign policy discussion about what kind of navy Canadians want and this country’s role in the world.

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Endnotes

- 1 Major capital projects, or ‘Major Crown Projects’ in federal government parlance, are defined by the Treasury Board Secretariat as those costing more than \$100 million (Canada 2006, 1).
- 2 Author’s calculations. The annual sustainment costs of the *Victoria*-class are estimated at \$325 million out of a \$21.9 billion (2019-20) defence budget (Canada 2020a).
- 3 The three known post-1945 successful submarine attacks against naval vessels are the 1971 Pakistani sinking of the Indian frigate *INS Khukri*, *ARA Belgrano* in the 1982 Falklands War, and the 2010 sinking of the South Korean corvette *ROKS Cheonan* by North Korea.
- 4 For example, the *Oberon*-class performed ISR roles in the North Atlantic, monitored Soviet nuclear ballistic missile submarines (“Boomers”), and provided vital intelligence to NATO (see Tracy 2012, 175, 196).
- 5 The Royal Canadian Navy’s current strategy describes a blue water navy as one that “possesses a balanced mix of platforms, including submarines, surface combatants, support ships and patrol vessels. It is a Navy structured around the ability to deploy and sustain a Naval Task Group, highly interoperable with allies, contributing meaningfully to joint action ashore, and the sustainment of joint operations from sea” (Canada 2017d, 9).
- 6 For an excellent example of geopolitical changes and how the relative decline of the United States has affected an ally’s defence procurement decisions, including submarines, see Norway (2020).
- 7 Author’s calculations based on data contained in the Submarines and Sub-Surface Warfare chart in IISS (2021).
- 8 An AIP under-ice capability was noted as early as 2006. (See Craven 2007, 27.)
- 9 Halifax’s Irving Shipbuilding Inc. and Vancouver’s Seaspan are two of the three designated shipyards for large vessel construction under the NSS. In 2019, the federal government selected Quebec’s Davie as the third NSS shipyard, but the company and Ottawa have yet to formalize a final agreement. (See Moss 2021.)



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