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Towards a Renewed Canadian Submarine Capability

Jeffrey F. Collins

Acquiring equipment for the Canadian Armed Forces (CAF) is a notoriously drawn-out and complicated process that typically can take up to 15 years or longer.[2] When it comes to Canada's four boat *Victoria*-class diesel-electric submarines, a decision on a new replacement will have to occur over the next five years to ensure the capability survives past the 2030s. Currently, neither the government's official defence policy, *Strong, Secure, Engaged* (2017) or the Royal Canadian Navy's (RCN) own strategic guidance, *Leadmark 2050*, earmarks a replacement for the *Victoria*-class.[3]

Both documents and the Department of National Defence's (DND) own procurement priority list, the *2018 Defence Investment Plan*, reiterate efforts to keep the *Victorias* in service until 2035 by which time the oldest of the subs will be nearly 50 years old. To make this happen, the fleet will undergo an estimated $2.5 billion modernization project backed by a new $1 billion to $5 billion maintenance contract.[4] The RCN aims to have the modernization contract in place by 2022.[5]

However, the price tag associated with a new submarine purchase in conjunction with the submarines' checkered history (see below) raise the question of whether replacing the *Victorias* is a politically viable option. Modern submarines, whether powered by diesel-electric, nuclear, or air independent propulsion (AIP) systems, are some of the most complex machines ever built. Only a handful of countries build them, key of which are the United States, the United Kingdom, Germany, Spain, France, Sweden, Japan, Russia and China. Moreover, as the Australian experience with the *Collins*-class has demonstrated, creating a domestic submarine manufacturing industry from scratch is fraught with start-up challenges, from securing local sources of steel, recruiting management and building expertise, and sorting out intellectual property negotiations.[6]

Even buying new submarines from a foreign supplier is not necessarily a cheap option. A 2003 DND audit noted that had Canada bought four new submarines in 1998, as opposed to buying second-hand British-made *Victorias* for $897 million, the price tag would have ranged from $3 billion to $5 billion.[7] In 2015 dollars, the bill would amount to between $9 billion and $15 billion.[8] In contrast, six new Arctic and Offshore Patrol Ships are currently being designed and built in Nova Scotia for $4.3 billion.[9]

This paper makes the case that the retention of a RCN submarine capability is not only desirable but also necessary. Beneath the negative headlines is the story of a force multiplier that can shape the strategic behaviour of an adversary, gather critical intelligence information, insert special operations units, and strengthen Canada's alliances. Notably, unique among all military assets the submarine requires a "disproportionate response from an adversary."[10] In making this argument this paper will begin with a brief historical overview of Canada's submarine service,

then explain the capabilities submarines bring to decision-makers, what capabilities need to be considered in a replacement and, finally, procurement options.

Canadian Submarines: A Brief History

Unlike its destroyers, frigates and supply ships, none of the submarines used by the RCN and Maritime Command were built in Canada. The country's first submarines were acquired in the oddest of circumstances. At the outbreak of the First World War, the Premier of British Columbia, fearing German raids on the Pacific coast, purchased two submarines built for Chile at a Seattle shipyard. The subs, named CC.1 and CC.2, ended up in Canadian hands for 40 per cent over their original purchase price, equivalent to that year's entire naval budget. The federal government bought two replacements in 1919 but post-war defence cutbacks led to their retirement and the end of a Canadian submarine capability for four decades.[11]

Shaped by the experiences of German U-boats in the Second World War and the demands of the Cold War naval build-up in the 1950s and 1960s, the idea of a Canadian submarine service re-emerged. It is worth remembering that 21 ships and 249 lives were lost in the Gulf of St. Lawrence alone in 1942 to German subs.[12] Lacking a domestic capability, Canada's immediate submarine needs in the 1950s were met by allies, including the UK's 6th Submarine Squadron based in Halifax, and the assignment of personnel to both Royal Navy and US Navy submarines.[13]

In 1958, senior naval officials made the push for nuclear subs but costs and opposition from the United States, particularly over nuclear technology transfers, in conjunction with a contentious domestic nuclear debate, killed the idea; even though the Lester Pearson government identified a two to three nuclear sub buy in the 1964 Defence White Paper.[14] The UK offered a more attractive and cheaper proposal: if Canada purchased three of its *Oberon*-class diesel-electric submarines, the RCN could take advantage of a global supply chain created for what would be 27 *Oberon* subs in use with six navies.[15] The government of John Diefenbaker approved of the acquisition project in 1962 and three *Oberons* entered RCN service between 1965 and 1967.[16] In the interim, Canada relied on two ex-US Navy subs, HMCS *Grilse* introduced in 1961 and replaced in 1968 with HMCS *Rainbow*, to build up its submarine capabilities.[17] The latter represented a return to West Coast submarine operations. Once cut in 1974 the navy did not have a permanent West Coast submarine capability until the arrival of the *Victoria*-class three decades later.

Between their commissioning in the mid-1960s and the early 1980s, the *Oberons* operated as an anti-submarine warfare training tool for the rest of the CAF, earning the nickname 'clockwork mice.'[18] Upgrades between 1979 and 1984 eventually turned the *Oberons* into a combat capability with MK-48 heavyweight torpedoes, a combat management system and modern sonar.[19] The *Oberons* distinguished themselves throughout the remainder of the Cold War by monitoring Soviet ballistic missile submarine activities in the North Atlantic. They also proved effective in constabulary roles in the early 1990s, monitoring fishing practices by US vessels in 1993 and again in 1995 with Spanish trawlers during the turbot dispute.[20]

Efforts at identifying a replacement for the *Oberons* began in the 1980s. Maritime Command initially proposed a new fleet of diesel-electric submarines but the government of Brian Mulroney, sensing domestic concern over US and Soviet submarine movements through Canadian-claimed Arctic waters, pushed for 10-12 nuclear-attack submarines. Announced in the 1987 White Paper, the nuclear plan met opposition from Canada's allies.[21] The United States, still opposed to sharing nuclear technology, thought the plan was beyond Canada's fiscal capacity, a viewed shared by the

British. The French were willing to share their *Rubis*-class design but only if the first four or five subs were built in France. The lost promise of Canadian offsets coupled with the project's price tag ($10 billion in 1989), a deficit crisis, unfavourable public opinion, and a changed global security environment, put an end to the nuclear submarine project in April 1989.[22]

The end of the nuclear buy did not halt the movement to replace the *Oberons*. The *Oberons* faced obsolescence by 2000.[23] With the other five *Oberon* users withdrawing their fleets, and the UK ceasing production of spare parts in the 1990s, Canada faced the possibility of losing its submarine capability altogether. It was under these unique circumstances that the *Victorias* were acquired. In 1994, the UK decided to turn to a nuclear-only submarine force thereby freeing up the~~ir~~ four recently built *Upholder* diesel-electric submarines for sale. Between 1994 and 1998, British officials made the pitch to Canada and a number of other allies. Pressure from two successive US Secretaries of Defense (who saw a modern Canadian submarine capability as useful for continental and transatlantic defence) and a stabilized federal fiscal situation eventually made it politically viable for the government of Jean Chrétien to sign off on a lease-to-buy option on the rechristened *Victoria*-class.[24]

Does Canada Need New Submarines?

The four *Victoria*-class submarines had an unenviable start – a fatal fire aboard HMCS *Chicoutimi* in 2004, flooding on HMCS *Corner Brook* in 2002, six years in dry-dock for HMCS *Victoria* due to electrical problems, a five-year refit for HMCS *Windsor* in 2007-12, and the running aground of HMCS *Corner Brook* in 2011. Canada's submarine fleet only achieved full operational status in 2015; 17 years after the Chrétien government approved the purchase.[25] The long time spent on 'Canadianizing' the subs and dealing with problems associated from their prolonged docking in saltwater in the UK have been well documented.[26] Unlike the *Oberons*, Canada is the only user of the *Victorias*, effectively making the British-made subs an 'orphan' class and generating difficulties in sourcing spare parts.[27]

It is tempting to view these challenges as vindication of criticism that submarines are not worth the expenditure of scarce resources. However, missing from this narrative is a discussion of the capabilities and value that submarines bring to Canadian decision-makers.

First, at a strategic level, submarines are the 'ultimate warfighting' tool in a navy's arsenal. Submarines give decision-makers the ability both to control an area of water and deter others from using it.[28] This uniqueness derives from submarines' physical and technological characteristics, chiefly the ability to remain underwater for long periods and to do so without detection. The *Victoria*s, for example, can operate in any weather conditions for periods of up to 45 days.

The offensive power of a torpedo in combination with such endurance and stealth abilities often means that the mere presence of a submarine, whether "actual or inferred," can change an adversary's strategic calculus.[29] During the 10-week Falklands War in 1982, for example, the British nuclear-attack submarine HMS *Conqueror* sunk the Argentine cruiser, ARA *General Belgrano*. Fearing more losses, the entire Argentine surface fleet returned to port, including its sole aircraft carrier, leaving the 9,000 strong garrison stranded to its fate on the South Atlantic islands.[30] The Royal Navy spent considerable amount of time, manpower~~,~~ and munitions on hunting down two Argentine diesel-electric submarines during the campaign.[31] Canada too has experienced such an impact, albeit on a smaller scale. During the 1995 standoff with Spain over the turbot fishery, officials at Maritime Command published a 'Notice of Intention,' indicating the

presence of an *Oberon*-class submarine in the contested waters. This action proved pivotal in de-escalating the confrontation between the two countries.[32]

Second, a modern submarine gives a government unique intelligence, surveillance and reconnaissance (ISR) capabilities. In fact, the ISR component is arguably a more significant capability than sinking ships, something that has only occurred on three occasions since 1945.[33] The advantages of using submarines in this role is that they are extremely difficult to detect when submerged, and can go where planes and surface ships cannot. One modern diesel-electric submarine, with good sonar conditions and utilizing a towed array, can cover up to a 125,000 square kilometres surveillance area over a 40 to 50 day period. In contrast, five to six ships are needed to cover 192,000 square kilometres in 30 days.[34]

In the post-Cold War era, navies have increasingly found themselves operating in the world's littoral zones. Here the dual effect of shallower waters and close proximity to shoreline makes surface naval vessels more vulnerable to anti-access/area denial (A2AD) weapons like cruise missiles and attack aircraft; factors recognized in *Leadmark 2050*.[35] Maritime patrol aircraft and helicopters are likely to encounter air defences in such environments. Today, countries big and small, from China and Russia to Iran and North Korea, have turned to A2AD weapons to counter the advanced and numerical capabilities of not only the US Navy, and specifically its aircraft carrier battlegroups, but also US allies. Even non-state actors have relied on A2AD weapons to devastating effect. For example, during the 2006 Second Lebanon War, Hezbollah crippled the Israeli corvette INS *Hanit* with an Iranian version of the Chinese C-802 Silkworm cruise missile.[36]

In this international security environment, the submarine remains a proven and invaluable tool in collecting ISR data. Modern submarines can detect high frequency, very high frequency and ultra -high frequency signals and cellphone transmissions. Because they are difficult to locate, they can remain in position for extended periods to gather both signal intercepts and monitor military and commercial maritime activity.[37] Diesel-electric submarines can sit at the bottom of harbours collecting such information.

Canada's *Oberon* and *Victoria* submarines have both performed ISR activities. The former monitored Soviet nuclear ballistic-missile submarines during the latter years of the Cold War and gathered intelligence on numerous fishing and drug enforcement missions in the early 1990s. In recent years, the latter have participated in anti-drug smuggling missions in the Caribbean. In 2018 HMCS *Windsor* completed a 133-day NATO deployment in the Mediterranean, performing counter-terrorism and maritime security monitoring.[38] Unfortunately, the secretive nature of ISR missions prohibits the sharing of much operational information; however, it is noteworthy that in May 2019 DND announced that the *Victorias* might be deployed to help enforce UN sanctions against North Korea.[39]

Third, owning a submarine capability brings prestige and intelligence access. As a member of the 'sub club,' Canada is a participant in a global Water Space Management regime that grants decision-makers access to information on allied submarine operations necessary to avoid mutual interference.[40] When not on missions, Canada's submarines have proven a valuable tool in strengthening alliances. The US Navy, which lacks the diesel-electric submarines commonly used by its adversaries, has regularly sought opportunities to train against Canada's submarines, including in 2017-18 in the western Pacific.[41]

Finally, the submarine remains the most effective means to counter another submarine. There is currently a proliferation of submarine acquisitions globally most notably in the Indo-Pacific region, an area home to most of the world's population, vital trade chokepoints (Malacca Straits, Strait of Hormuz), and competing maritime territorial claims (e.g., South China Sea). In a region

without a robust security framework akin to NATO, nationalism and historical animosities are fueling a naval armaments race.[42] Twelve countries in the region operate over 170 submarines, including China, Japan, Singapore, Australia and South Korea.[43] It is for these reasons that the RCN views submarines as the "dominant naval platform for the foreseeable future."[44] With RCN units increasingly deploying to the region, the ability of Canada to supply a submarine is critical to allied deterrence, ISR and training capabilities for the immediate future.

What Capabilities Would Canada Need?

The deterrence, ISR and alliance benefits of submarines are clear. Nevertheless, going forward on any submarine replacement project will have to consider the trade-offs involved in each of the following five capabilities.

Propulsion

There are three sources of submarine propulsion: diesel-electric; nuclear; and air-independent propulsion (AIP). A propulsion system is critical to a submarine's endurance, its operational abilities, stealth, and acquisition and support costs. Nuclear submarines have the longest endurance capacity of any submarine and are capable of transiting under Arctic ice. However, these subs are limited in littoral operations due to their larger size (both the US Navy's *Virginia*-class and Royal Navy's *Astute*-class submarines are more than 7,000 tonnes compared to the 2,400 tonne *Victorias*) and the fact that they require access to deep cold water for reactor cooling. In addition, their larger size and constantly operating reactor mean a larger noise signature than either diesel-electric or AIP submarines.[45]

Moreover, nuclear submarines are not politically or fiscally feasible in Canada give the long history of public opposition and costs associated with prior attempts. Diesel-electric propulsion has been the mainstay of the RCN submarine service. Among some of the quietest naval vessels in operation, diesel-electric submarines run on electric power when submerged, only breaching the surface to 'snorkel,' that is, to recharge their batteries. The downside is that the sub's range is limited to its fuel supplies and it is unable to travel under Arctic ice due to the need to snorkel (see next point).

Among the various AIP systems in service, fuel-cell technology represents the most promising. Some systems, like those used in Germany's Type-212 submarines, are effectively noiseless with the only sound emanating from the shaft and propeller. The Type-212 relies on electric-catalyst fuel cells and lithium-ion batteries and can travel up to 2,400 kilometres, while remaining underwater up to three weeks.[46] But the AIP too has its limitations. Its speed is relegated to short bursts and its endurance is limited to the storage space for its complex fuel supplies. Fuel-cell technology is also expensive, and the AIP technology has not advanced to the point that a sub can safely travel under Arctic ice. Although Japan has adapted Sweden's Stirling engine to its larger *Sōryū*-class, to date, AIP engines continue to be designed for smaller European submarines (i.e., less than 2,000 tonnes) aimed at shorter patrols operating within close proximity to support infrastructure. This does not suit Canada's operating environment which would involve long distances, far from support infrastructure.[47] Australia, which shares many of the long-range and

geographic realities as Canada, has opted for a diesel-electric version of the French nuclear *Barracuda* design over an AIP system for its 12 new submarines.[48]

Arctic Ice

Related to propulsion is the need for a submarine to transit under Arctic ice. Various RCN documents envision a navy with the ability to operate in all three of Canada's oceans. *Strong, Secure, Engaged* stresses the need for the RCN to operate in the Arctic. Of course, the attempt to build and buy nuclear submarines in the 1987 White Paper was premised on the ability to patrol frozen Arctic waterways. To date, diesel-electric and AIP-equipped subs can only "work near the ice-edge to deny access to the Arctic," which may be sufficient for the time being given the modernized CP-140 Aurora maritime patrol aircraft and advances made in under-ice surveillance systems like those tested in the Canadian Arctic Underwater Sentinel Experimentation.[49] With a new submarine likely to be operational over a 40 to 50 year lifespan, the impacts of climate change and progress in the development of unmanned underwater vehicles may make the need for ice capability less necessary. It is also possible that the AIP technology will evolve to the point of making it feasible and safe to conduct under-ice patrols.

Fleet Size

The number of hulls a navy has determines fleet readiness. European naval policy scholar Jan Joel Andersson recommends a minimum of four submarines to allow for one or two submarines to be on standby or deployment ready with the remainder in maintenance or used for crew training.[50] However, the experience of the *Victoria*-class highlights the problems of relying on such a small fleet split between two distant coasts. Further, unless the subs are built domestically, a small fleet of foreign-built boats tends to mean depending on technical support from the country of origin.

It is telling that numerous White Papers and Parliamentary reports have consistently recommended a submarine fleet larger than the current four. In the early 1980s, DND sought six new diesel-electric submarines before being sidelined by the Mulroney government's plan for a dozen nuclear subs. The goal of six subs re-emerged in the 1992 Canadian Defence Policy and the 1994 Defence White Paper.[51] A 2017 Senate report recommended 12 AIP-powered submarines split evenly between the West and East Coast fleets. This arrangement would allow for the deployment of six subs at a high state of readiness, two to four in deep five-year maintenance, and two to four in either training, returning or preparing for operations.[52] Twelve may be out of the question given cost concerns but thought is needed on fleet readiness.

Crew Accommodations

Modern militaries like the CAF require highly trained and experienced personnel to operate sophisticated equipment, often in austere conditions far away from home. The unique nature of submarine operations places an added strain on personnel recruitment and retention with crews deployed underwater in cramped conditions for extended periods without regular communications. Allied navies with similar or larger submarine fleets than Canada's have run into this problem.

The Royal Navy has sometimes deployed its submarines with less than half their crew complement and the Netherlands has struggled to maintain crews for three out of its four *Walrus*-class submarines.[53]

Crippled by maintenance problems, the Royal Australian Navy (RAN) struggled in the 2000s to crew just one of its six *Collins*-class subs and turned to bonuses to attract and keep crews.[54] With the RAN planning to build 12 new submarines, concerns are again mounting on how to meet the new human resource demands.[55] Although no one expects the navy to be offering five star accommodations, "lifestyle demands," in the words of one former Canadian submariner, "must be addressed."[56] Notably, a key priority of the upcoming *Victoria*-Class Modernization project is to "improve habitability and deployment conditions for submariners."[57]

Littoral Operations

Monitoring port activity, dropping off and retrieving special forces operators, and undertaking anti-smuggling activities are just some of the littoral missions with which diesel-electric or AIP submarines are tasked.[58] Not only are littoral operations expected to continue but the proliferation of A2AD weapons in regions like the Middle East and East Asia gives incentive to navies to reduce the exposure of their frigates, destroyers and supply ships. The upcoming *Victoria*-Class Modernization project carries a new focus on supporting CAF operations ashore but few specifics are provided.[59]

Nevertheless, if there is a gap within existing RCN submarine assets, it is in the absence of a limited surface-to-surface missile strike capability. Numerous allies including Australia, the Netherlands and Germany rely on such missiles to hit targets ashore or defend against surface ships. The *Victorias* originally came with a Harpoon anti-ship missile capability but this was removed. Obtaining this capability would not be unique to the RCN's submarines; in incorporating littoral operational experience, the recently completed *Halifax*-Class Modernization project included the introduction of a modernized Harpoon missile capable of hitting targets ashore.[60]

Procurement Process: Options?

The history of Canadian submarine procurement has been one of buying or leasing from US and UK sources. Outside of the *Oberon* purchase in the 1960s, Canada's submarines have been acquired second-hand. No matter the procurement model adopted, buying new submarines will not be cheap and will have to confront the real obstacle – i.e., Canadian public and political opinion. Negative headlines on Canada's submarines aside, it does not help that submarines have a reputation as offensive weapon systems designed to sink ships. Former Foreign Affairs Minister Lloyd Axworthy even deemed them 'un-Canadian.' There is also the reality of opposition within naval ranks from those fearing the loss of surface fleet capabilities in exchange for submarines, or from the other armed services.[61] The Mulroney government's efforts at getting nuclear submarines in the 1980s, for example, came at the expense of a third batch of *Halifax*-class frigates.[62] Assuming that nuclear submarines are not an alternative, a Canadian government will need to consider four options in the coming five years.

Build Under the National Shipbuilding Strategy

It is noteworthy that the National Shipbuilding Strategy (NSS), launched in 2010 with a multi-decade focus on establishing a naval and coast guard shipbuilding industrial base, does not incorporate submarine procurement in its long-term plans. Opening the NSS up to include submarine construction is one way forward; mirroring the overall promise of rebuilding domestic industry and addressing the political concern about keeping the benefits within Canada. There clearly remains flexibility within the NSS. In 2019, the Trudeau government announced the expansion of the NSS to include a third yard (likely Davie in Quebec) and added another $15.7 billion in coast guard shipbuilding projects.[63]

However, the final price tag for a build-in-Canada approach is unknown, which raises the issue of 'sticker shock' politically. Australia is attempting to build 12 large diesel-electric submarines for $A50 billion (roughly $46 billion Canadian). That project has highlighted the challenges with securing intellectual property rights on a foreign design, recruiting specialist trades people, and locking down a domestic supply chain.[64] On the other side, building domestically, especially with an existing foreign design, would minimize the supply chain problems associated with an 'orphan' class like the *Victorias* and ensure the preservation of a knowledgeable domestic industrial base for future maintenance and upgrades.

Buy Overseas Off-the-Shelf

This is likely the most cost-effective but also the most politically contentious option. Spending billions on submarines in foreign shipyards will almost certainly make the project a political target by opposition and domestic industry interests. In addition, as the *Victoria*-class submarines have shown, buying off-the-shelf still may require Canadianizing the new vessels, itself a time-consuming and costly project. With the majority of allied submarine exports originating from countries like Germany and France, Canada would have to consider the trade-offs. Thus purchasing what are generally smaller submarines built for Baltic and Mediterranean missions might not match with operational limitations in the Pacific and Atlantic, and might mean more money spent on creating ashore support infrastructure.

Collaborative Build with a Foreign Partner

Australia, Japan and Spain are some allies that are building large diesel-electric or AIP submarines that hypothetically meet Canada's long endurance and operational requirements. It may be possible to negotiate the building of submarine parts in those overseas yards for assembly in a Canadian yard. Australia and New Zealand did this successfully with the *ANZAC*-class frigates in the 1990s.[65] The downside is a loss of local economic offsets and possible intellectual property complications but, at a minimum, Canadian industry would develop the expertise and reduce the likelihood of operating an orphan class.

No Replacement

Denmark scrapped its century-old submarine service in 2004 as a cost-saving measure.[66] Canada could do the same. It could then use monies set aside for submarine training and maintenance to invest in new maritime patrol aircraft, satellites or unmanned underwater vehicles. However, the trade-off would be immense: unless Canada invested heavily in unmanned underwater vehicles, it would return to a pre-1961 position of relying on allies for underwater surveillance and defence, with political and defence officials missing a critical ISR asset. As a country confronting a changing geopolitical climate, great power interest in the Arctic, and an unstable post-1945 alliance structure, Canada would be at risk of being unable to monitor and enforce its own waters. Moreover, the highly skilled training and technical knowhow needed to operate and maintain a submarine would be gone. Restarting a submarine service from scratch is arguably more cost-prohibitive than replacing old submarines with new submarines.[67]

Conclusion

If Canada is to have a submarine service beyond 2035, at some point within the next five years a decision will have to be made on whether the *Victorias* will be replaced. If Ottawa is serious about a domestic NSS-like sub build, then Australia's current plans for its 12 *Attack*–class submarines is illustrative of the timelines involved. With a 50-year partnership agreement in place with French builder Naval Group (signed in February 2019) and capital equipment contracts already awarded, construction of the first submarines will only begin in late 2023, with the subs entering RAN service in late 2034.[68] In order to plug any capability gap with the retirement of its existing *Collins* submarines in the 2030s-40s, construction will be staggered so that the last submarine enters service in the early 2050s.[69]

Canadian decisions-makers face difficult constraints. Canada's closest strategic allies and previous sources of new or surplus diesel-electric submarines, the United States and the UK, have turned to nuclear-only submarine fleets. The handful of countries that operate large non-nuclear submarines along Canadian lines are currently pursuing replacement plans (Japan's *Sōryū* comes to mind). With no existing domestic institutional knowledge in industry or government on building submarines, perhaps the most politically and militarily effective option is to enter a collaborative build with a proven foreign builder with some parts built overseas but assembled in Canada. However, the cost remains a factor. The Senate may recommend a 12-boat fleet, but this is beyond cost prohibitive. In keeping with past White Paper recommendations and operational experience, a four to six submarine fleet is necessary to ensure adequate submarine readiness on both coasts. It is difficult though to discern where the procurement funding will come from given the need to advance big ticket items like the estimated $70 billion Canadian Surface Combatant and the $19 billion Future Fighter Capability.[70]

Unmanned underwater vehicles (UUVs) are one possible alternative; the United States, Russia and China have all invested heavily in UUVs, especially in developing anti-submarine warfare capabilities. UUVs are attractive not only from a personnel and cost perspective but also in terms of risk calculations. Manned submarines are incredibly complex machines operating in a hostile environment where the margins of error are slim. The 2017 loss of the Argentine submarine ARA *San Juan* is only one of the more recent tragic examples of this. Still, UUVs are a nascent technology, limited by battery life and, because of seawater density, communications. Moreover,

like their airborne counterparts, UUVs are envisioned as complementing manned submarines and surface combatants as opposed to replacing them.[71]

Despite challenges, Canada's submarine service has proven the unique and vital capabilities that that come from possessing a versatile underwater naval platform. In a world of uncertainty, the question going forward is whether Canadian decision-makers will commit to renewing this capability.

Notes

1. Jeffrey F. Collins, Fellow, Canadian Global Affairs Institute and Research Fellow, Centre for the Study of Security and Development, Dalhousie University. Email: jeff.francis.collins@gmail.com. This article is not to be republished without the permission of the author and the Naval Association of Canada.
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