CANADIAN NAVAL REVIEW

VOLUME 17, NUMBER 1 (2021)

The Science of Vague Assumptions: The Sea Mine and Its Future

Modernizing Anti-Submarine Warfare: A Systematic Journey

Artificial Intelligence: How Can the RCN Benefit in the Near Term?

Canada-US Defence Relations and the CSC: A Ship Too Far?

Our Sponsors and Supporters

Canadian Naval Review (*CNR*) is a 'not-for-profit' publication depending for funding upon its subscription base, the generosity of a small number of corporate sponsors, and support from the Department of National Defence. In addition, *CNR* is helped in meeting its objectives through the support of several professional and charitable organizations. Without that corporate support *CNR* would not be able to maintain its content diversity and its high quality. Corporate and institutional support also makes it possible to put copies of *CNR* in the hands of Canadian political decision-makers. The help of all our supporters allows *CNR* to continue the extensive outreach program established to further public awareness of naval and maritime security and oceans issues in Canada.

(www.navalassoc.ca)

(www.canadasnavalmemorial.ca)

(www.navyleague.ca)

To receive more information about the corporate sponsorship plan or to find out more about supporting *CNR* in other ways, such as through subscription donations and bulk institutional subscriptions, please contact us at info@navalreview.ca or coord@navalreview.ca.

CANADIAN NAVAL REVIEW

VOLUME 17, NO. 1 (2021)

BMIG StFX BRIAN MULRONEY INSTITUTE OF GOVERNMENT
Today's Policy Questions, Tomorrow's Policy Leaders

The editorial offices of *CNR* are located at the Brian Mulroney Institute of Government, St. Francis Xavier University in Antigonish, Nova Scotia. The mailing address is: Canadian Naval Review, C/O Adam Lajeunesse, Lane Hall, St. Francis Xavier University, 2330 Notre Dame Ave., Antigonish, Nova Scotia, Canada, B2G 2W5

Email: info@navalreview.ca
Website: www.navalreview.ca
Twitter: @CdnNavalReview

Canadian Naval Review is published by the Brian Mulroney Institute of Government at St. Francis Xavier University. It is a professional journal examining a wide range of maritime security issues from a Canadian perspective. In particular it focuses on strategic concepts, policies, operations, history and procurement of the Canadian Navy, plus national security in general and marine/ocean affairs. This initiative brings together members of the Canadian defence and academic communities.

Canadian Naval Review has three primary objectives:

- provide a public forum for the discussion of the maritime dimension of Canada's national security;
- provide a public forum for the discussion of Canada's naval and maritime policies; and
- provide a source for the public examination of Canadian naval and maritime history and for the development of lessons learned.

The material included in *CNR* is presented for the professional and general education of the readers. Articles, commentaries and opinion pieces are invited from the widest possible spectrum for the purpose of informing, stimulating debate and generally challenging readers. The opinions expressed by the authors do not necessarily reflect the opinions of the Editor, Editorial Board, Brian Mulroney Institute, the Department of National Defence, or the Canadian Navy.

Articles, opinion pieces, book reviews and letters may be submitted via email or mailed (with an electronic copy) to the address given above. Send to the attention of the Editor, Dr. Ann Griffiths. Articles are to be in Word or WordPerfect format and no longer than 3,000 words. Articles must not have been published elsewhere. Citations should be kept to a minimum and articles must be accompanied by a 100-120 word abstract. Opinion pieces are to be 1,000-1,500 words. Book reviews are to be 500-750 words. Photos may be submitted with articles or commentaries but they must be at least 300 dpi, at an equivalent size to 5 by 7 inches, and internet images cannot be used. Intellectual copyright will remain the property of the author, however, the right to re-publish articles initially published in *Canadian Naval Review* remains with the Editorial Board. Articles and commentaries written in French are welcome and, if accepted, will be published in French.

Credit: Corporal David Veldman, Canadian Armed Forces

*Northern lights flare above the first Arctic and Offshore Patrol Vessel, HMCS **Harry DeWolf**, during cold weather and ice trials near Frobisher Bay, Nunavut, on 21 February 2021.*

Contents

Editorial

One More Time: Sexual Misconduct in the CAF

As a woman, I'm discouraged that we keep hearing about sexual misconduct in the Canadian Armed Forces (CAF). This behaviour has been acknowledged for years, indeed since women began joining the military in significant numbers. Training programs have been instituted, and studies and reports have been undertaken. And yet here we are. After reports in 2014 of wholesale problems, former Supreme Court Justice Marie Deschamps was asked to investigate and make recommendations on an action plan. She released her report in 2015. Shortly after this, the incoming Chief of the Defence Staff (CDS), General Jonathan Vance, initiated *Operation Honour*, with the goal of eliminating inappropriate sexual behaviour in the CAF. As well, the Deschamps recommendations were included in *Strong, Secure, Engaged: Canada's Defence Policy* in 2017. And, yet, once again, here we are.

Some positive changes have been made. The military now takes complaints more seriously, there are new processes, organizations and training. There are agencies for victim services and support, and military police have received training in how to investigate sexual misconduct. As well, new systems within the military were implemented to ensure allegations and complaints are investigated more rigorously. So the past few years have not been wasted. But due to some highly publicized cases at the top levels of the CAF, *Op Honour* has come to an ignominious end (in the awkward phrasing of the acting CDS, the operation 'has culminated'). And sexual misconduct is still in the news.

This is a difficult subject with many elements and underlying currents. It is particularly difficult in the military because of the long traditions that personnel value deeply, the long history of being a male environment, the ethos of military comradeship, and the strong hierarchical command structure. But, it should be noted, there is also a long tradition of 'duty with honour' in the military, and there is nothing honourable about sexual misconduct.

There are areas of this topic that are black and white, and many areas that are grey. An area that is absolutely black and white is the issue of violence. There is far too much violence against women in society. No one should have to work in an environment that is degrading, toxic or violent. No one in a hierarchical organization should be allowed to take advantage of their rank and power to harm or abuse subordinates. The military should stress over and over again that no violence is acceptable. Any service member who uses physical violence against a woman (or a minority, or anyone else (outside of combat situations,

Credit: Cpl Stuart Evans, Borden Imaging Services

*Members of NRU **Asterix** and HMCS **Regina**'s Air Detachment conduct training with a CH-148 Cyclone helicopter during **Operation Projection** in the Pacific Ocean, 7 July 2019.*

Credit: Cpl Ryan Moulton, 8 Wing Imaging

Major General, now Lieutenant General, Jennie Carignan is seen here in Baghdad during a ceremony at which she assumed command of the NATO Mission Iraq on 26 November 2019. Carignan will lead a new organization within the Canadian Armed Forces to oversee professional conduct and culture.

of course)) should know that they will be released forthwith. But to avoid uncertainty and confusion, there needs to be clear differentiation among types of behaviour – for example, differentiating between a violent sexual assault and making a joke or sexual comment – and severity of punishment which should range from criminal charges to administrative penalties.[1]

However, we should remember that in Canada we have a legal tradition of innocent until proven guilty. Complaints must be thoroughly investigated and should not be treated as a political piñata. Until allegations have been examined, and proven, we should stop the character assassination of people, some of whom have spent their lives in the service of their country.

This brings us to another black and white issue – the complaint process. As noted, under *Op Honour* new processes and agencies were formed. But all the complaint systems in the world will not help if a woman has to complain up the chain of command, particularly if the person up the chain of command is the person who is responsible for the misconduct in the first place. The Deschamps report's third recommendation was to "create an independent center for accountability for sexual assault and harassment outside of the CAF with the responsibility for receiving reports of inappropriate sexual conduct...."[2] This was not implemented. There has long been resistance in the military to this. But it must happen – complaints cannot be handled within the military. Neither the CAF nor the Department of National Defence (DND) should be relied upon to address this issue. An independent body, perhaps reporting directly to Parliament, should be given a regular oversight and monitoring role. In response to pressure, in March 2021 the government announced that an external independent body would be formed to investigate allegations of sexual misconduct in the CAF. This is a good start, but adequate resources and trained personnel must be allocated – it is not enough to form an independent body if you starve it of the resources to make it effective.

But for all the black and white issues, there are many grey issues. It's discouraging that the men at the top of the CAF have complaints against them but it's also not surprising. The military has traditionally been male-dominated and changes occur only slowly. Big organizations – in both the public and the private spheres – are inherently resistant to change. So, while sexual mores change and ideas about acceptable behaviour change, big organizations are slow to do so. Women are still working their way up to positions of power. In essence this means that oftentimes men are given the lead on this, and in some cases their enthusiasm for pushing to change the organizational culture has been underwhelming.

The question of leadership is key in any organization. Canada has been at peace for many years but that doesn't mean that war will not happen. We need the best people at the top of the military but how should 'best' be defined? Some have argued that military personnel should be promoted based, not on successfully completing their missions, but on how they treat their people.[3] Do we want the top echelons of the military to be populated with people whose claim to fame is that they have not offended anyone throughout their career? Being good at your job should be the defining element, but how you treat your subordinates is obviously part of that. Good leadership has many elements but right now a firm commitment to ending sexual misconduct has to be one of them.

Some accounts indicate that women in the CAF are seething with anger. I don't know if this is the case but, as a woman, I would understand if it was. It is infuriating to have to deal with demeaning, degrading and confidence-destroying behaviour – never mind violence – from male colleagues. I'm sure most women have at some point been

dispirited as their authority and confidence are undermined. We must, however, be prepared for blowback. Will male service members form a seething group of resentment at women and minorities who are seen to be treated differently than they are? The government is encouraging greater recruitment of women into the CAF, but will men take a pass? And, even more worrisome, will it lead to the growth of right-wing extremism in the military?

I'm sorry to raise this, but we cannot talk only about men behaving badly. Women too can succumb to power and abuse it. Abuse of power has no gender. As well, women can sexually harass people. I've been with female friends who have laughingly made disparaging or sexual comments to/about male staff in various circumstances. I can see that men might see a double standard at play here – the behaviour I've witnessed in women would be completely unacceptable if a man did it.

At the end of April 2021, two changes were announced by the Minister of National Defence. First is the establishment of the Chief, Professional Conduct and Culture, a position to be held by Lieutenant-General Jennie Carignan, "to lead a fundamental transformation in the way systemic misconduct is understood and addressed in the Department of National Defence (DND) and the Canadian Armed Forces (CAF)."[4] We will have to wait and see what happens with this. And, second, (another) former Supreme Court Justice, Louise Arbour, was appointed to undertake (another) independent review of sexual misconduct in the CAF and make recommendations (again), this time about an independent reporting system. While I'm a fan of Madame Arbour, this sounds like the same tune that was played in 2014. Excellent reports are written, insightful recommendations are made, and the government of the time and CAF leaders say some nice words. Then the government/Minister of Defence and the CAF pick and choose among the recommendations, ignoring the inconvenient ones, half-heartedly implement them, and a few years later sexual misconduct is back in the media. One more time, with feeling.

Bottom line? The CAF must do something about this problem. We cannot keep revisiting it. It is demoralizing for everyone. In financial terms, if nothing else, the government cannot afford to keep ignoring the problem – it is now paying $900 million to settle claims going back to the 1980s.[5] It may not be possible to eradicate 100% of the behaviour, but the CAF must do better. *All* CAF members – and civilians working for the CAF – should be treated with respect. The solution should not be to claim that *Op Honour* has been a failure and begin to re-invent the wheel. Whatever replaces *Op Honour* should not throw the baby out with the bath water, it must keep the good

Credit: Government of Canada

Former Supreme Court Justice Marie Deschamps led an external review into sexual misconduct and harassment in the Canadian Armed Forces in 2015. Her report recommended a series of changes that have been implemented to varying degrees.

Credit: Remy Steinegger, World Economic Forum

Former Supreme Court Justice Louise Arbour is seen while President and CEO of the International Crisis Group in 2011. She was appointed in April 2021 to lead the latest external review into sexual misconduct in the Canadian Armed Forces.

elements of the program. What we need is leadership in the CAF on this – *real* leadership; in other words, military leaders who are committed to pushing for change. The CAF must ensure that addressing sexual misconduct is part of the package from the time of recruitment, through training and throughout careers. A complaint process outside of the chain of command must be established and given sufficient resources to function. It must be scrupulous in investigating all claims but it must not be glacially slow (hence the need for sufficient resources).

I'm a political scientist, I'm watching as democracy is under threat and authoritarianism flourishes and becomes more aggressive. We cannot afford to ignore the small flames that are starting to flicker around the world. We need to get this sorted out so the CAF can rebuild trust, both internally and externally, and form an esprit de corps that includes all members.

I really hope that we will not be revisiting this topic again in five years.

Dr. Ann Griffiths
Editor, Canadian Naval Review

Notes

1. See Tony Battista, "Investigative Independence and Accurate Terminology," *Frontline*, 7 April 2021.
2. Marie Deschamps, "External Review into Sexual Misconduct and Sexual Harassment in the Canadian Armed Forces" (Deschamps Report), 27 March 2015, Recommendation #3.
3. For a discussion of this, see Lee Berthiaume, "Canadian Armed Forces Misconduct Allegations put Spotlight on Hostile Sexualized Culture," The Canadian Press, 13 March 2021.
4. See Department of National Defence, "Chief, Professional Conduct and Culture," 29 April 2021, available at Chief, Professional Conduct and Culture - Canada.ca. See also the Statement by the Minister of Defence on "Culture Change in the Canadian Armed Forces and Department of National Defence," 29 April 2021.
5. See David Pugliese, "Approximately 4,600 File Claims of Sexual Misconduct or Discrimination against Canadian Military," *Ottawa Citizen*, 14 April 2021.

The Science of Vague Assumptions: The Sea Mine and its Future

Lieutenant (N) Sebastian Harper

Credit: Commander SNMCMG 1

Participants of the multinational mine clearing operation Ocean Spirit 21 pose around a mine disposal explosion in the Baltic Sea in April 2021.

Ninety-five per cent of the world's commerce moves by sea through strategic sea lines of communication (SLOCs) that will only become busier as natural resources and fossil fuels become scarcer. Contrast this statistic against the advanced assortment of sea mines in the armories of many of the states which dominate these shipping lanes, and there is due cause for concern for many maritime states.

Since their adoption by navies in the 19th century, sea mines have been considered an oddity; strange contraptions which were largely deemed ineffective, 'ungentlemanly' or unfair, not a *real* way to fight a war at sea. Academic and military literature have, for the most part, reflected this, with sea mines often taking a back seat to more exciting tactics and weapons systems. Sea mines care not for seamanship prowess, number of guns, missiles, expensive targeting systems or how 'gentlemanly' one considers oneself. Most navies place mine warfare firmly on a back burner, a sideshow area of warfare that is left to decay until a multi-million dollar warship is crippled by a cheap mine. Why? History has taught us time and again of the effectiveness of the sea mine. Navies, however, choose deliberately to ignore this, investing millions in new missiles, targeting systems, jet fighters, etc., instead of upgrading their aged mine warfare forces in the face of increasing global mine stocks which pose a threat to both military and commercial shipping alike.

Now that mine strikes are once again occurring in the Strait of Hormuz, where is the future of naval mine warfare headed? This article discusses this question by taking a look at mine warfare and how it will fit into future maritime conflict. In doing so, it will tangentially address the inattention paid to naval mine warfare by Western navies.

There is no agreed upon international definition, but NATO defines a sea mine as "an explosive device laid in water, on the seabed or in the subsoil thereof, with the intention of damaging or sinking ships or of deterring shipping from entering an area."[1] Naval mine warfare (NMW or MW) includes the laying of mines ('mining') as well as the defeating of mines (mine countermeasures (MCM)). Although NATO excludes limpet mines or water-borne Improvised Explosive Devices (IEDs) from its sea mine definition, this article will include them in its examination of MW. This is because recent events point to a seamless employment of mines, limpet mines and water-borne IEDs as an asymmetric weapon system employed by states and non-state actors alike.

The widespread use of sea mines, historically speaking, has been relatively short; from about 1861 to present day. In that time, the technology surrounding sea mines has naturally progressed, but the concept remains largely unchanged. A basic sea mine has five main components: the switch, initiator, explosive, power source and case. There are seven general mine types: moored, bottom, drifting, limpet, submarine launched/mobile, rising/rocket and improvised mines. Mines are typically actuated by one

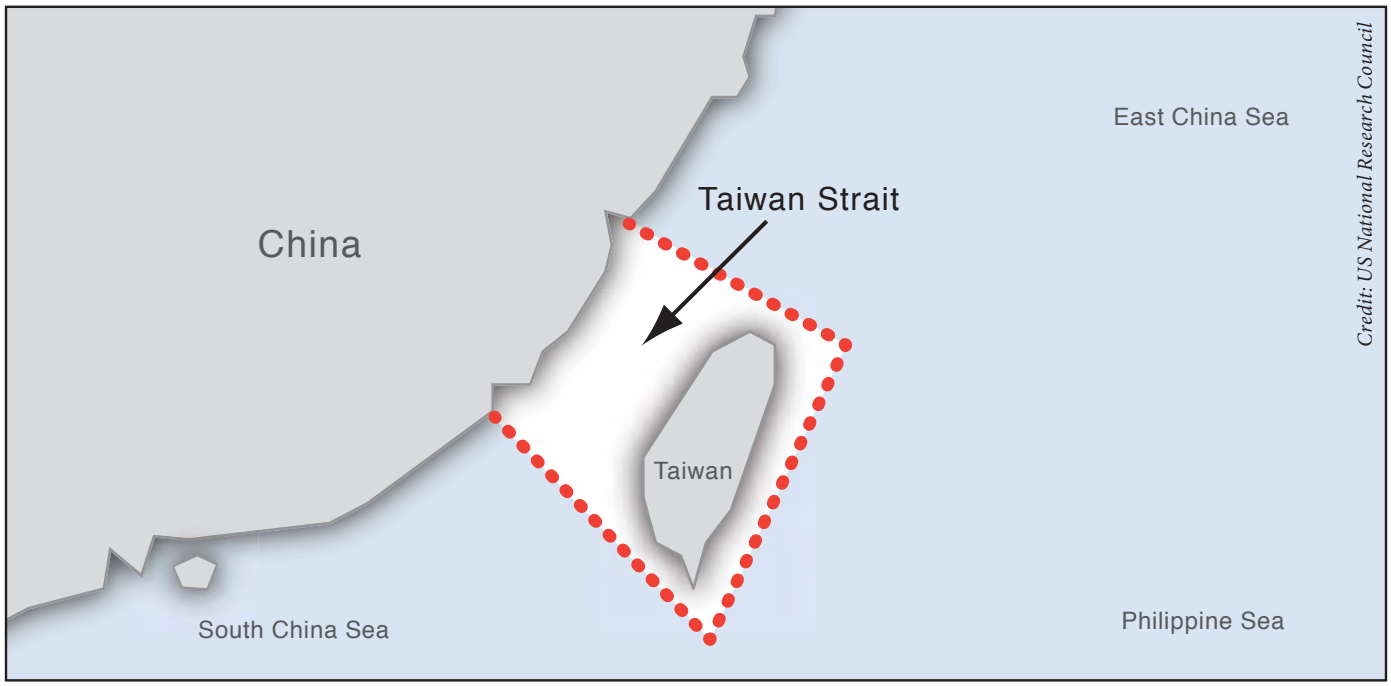
of two methods: contact or influence (the acoustic, magnetic, hydrostatic or seismic influence of a passing ship or submarine). Influence sensors can be tuned to target ships generally or focus on a specific type or class of ship, or even a single specific ship/submarine. Most modern mines can also be remotely controlled, armed, disarmed or fired, often employed as a form of pre-emptive self-defence.

Sea mine effectiveness is limited only by the technology available and the ingenuity of mine designers. Modern mines are effective from the surface to 400m in depth, lending themselves well to use in narrow seas, choke points and littoral waters.[2] In order to target adversarial shipping more effectively and evade MCM forces, we can expect the mines of tomorrow to be smarter, more powerful and largely autonomous.

Mines began appearing regularly in naval warfare in the late 19th century, coinciding with the naval technological revolution which brought about steam power and ironclad warships. Perhaps the most famous early occurrence of mining took place at the Battle of Mobile Bay during the American Civil War. Union Admiral David Farragut, seeing one of his ships strike a mine (then called torpedoes), spurred his ships on to victory by allegedly shouting "Torpedoes? Damn the torpedoes, four bells, Captain Drayton, go ahead. Jouett, full speed!" However, it wasn't until the Russo-Japanese War in 1904-1905 that mines were used extensively, in this case to mine Russian ports. This resulted in considerable losses for belligerents and commercial shipping alike.

Since then, mines have been present in most naval conflicts including the First World War, the Second World War, Korea, Vietnam and the first Gulf War. They remain a part of naval stockpiles of many states. Some of these states dominate strategic choke points of SLOCs on which the world economy depends. Because of this, mines, even stockpiled, carry with them a significant deterrent. Iran regularly reminds the world of the fact that it dominates the Strait of Hormuz with semi-routine sea mine sabre rattling. Whenever this occurs, it is enough to make oil prices jump as shipping costs rise. Mines need not even enter the water to have this effect. The simple fact that they exist coupled with the hint of them being laid would be enough to initiate an MCM effort to improve the safety of the sea lane.

Mines are effective and relatively cheap especially when compared to other weapon systems designed to cripple or sink a ship. For example, a block II Harpoon anti-ship missile cost $1.2 million USD[3] (2017) and a Mk 48 torpedo cost $3.5 million USD (1998).[4] By comparison, a sea mine can cost as little as $2,000 USD (1997), but more basic mines are far cheaper and water-borne IEDs are cheaper still.[5] Sea mines have been responsible for seriously damaging or sinking four times as many US Navy ships than any other weapon system since the Second World War.[6] One notable example of this stark cost comparison occurred in the First Gulf War in 1991. The coalition naval task group assigned to shore bombardment and, ironically MW, in support of the amphibious invasion ran into an Iraqi minefield in which USS *Princeton* and USS *Tripoli* both struck mines. In this case, two Iraqi mines (one valued at $10,000 USD (1993) and the other at $1,500 USD (1993)) inflicted $21.6 million USD (1996) in damage and removed two major warships from the task group for the



Potential mining of Taiwan Strait.

Potential mining in the Strait of Malacca.

majority of the conflict.[7] This incident was an awakening for the US Navy which caused it to overhaul its MW capability completely in reaction.

There are three main areas that will be of significance to the future of NMW because of their geographic importance, the investment in regional MW technologies, and trends in MW tactics. These areas are: the Asia-Pacific region; the Strait of Hormuz/Red Sea; and the Baltic/North Seas.

Asia-Pacific Region

For the first time, Asian countries are investing more on their navies than Western or NATO countries. This investment extends to areas of MW, promising that this region will be at the forefront of future MW technology and tactics.[8]

On the Korean Peninsula, North Korea maintains a large, albeit aged, Soviet mine stockpile and intelligence indicates that if conflict erupts between North and South Korea, mines will be employed by the North to choke off South Korea. This has prompted both South Korean and US forces in the region to invest heavily in and routinely exercise their MCM capability.

China's assertiveness over the South China Sea and its recent rapid increase in naval investment leads many to speculate that China may look to employ its large mine stockpile heavily in defending its sovereignty claim in the South China Sea – particularly in the defence of its 'nine dash line,' the Spratly Islands and in a potential blockade of Taiwan. China is also increasing its dominance over the Strait of Malacca, the second busiest global SLOC, on which most Asian economies depend – presently, all Asian states depend wholly on the Strait of Malacca for their flow of oil. It is thought China may employ proxy asymmetric sea denial tactics to control this SLOC. It has also been speculated that China may employ some of its newly acquired unmanned underwater systems unconventionally to interdict resource extraction and critical underwater infrastructure like pipelines and communications cables of both its regional and Western competitors.[9] This has Western-aligned regional powers working to beef up their MCM forces in response.

Strait of Hormuz/Red Sea

The Strait of Hormuz is the busiest SLOC in the world. Many non-regional states, including American, European and Asian states, are dependent on the flow of oil through this strait. Iran's unpredictability and its large mine stockpile has many states concerned for their economic security. Iran's use of mines in conflict is well documented and recent tensions with the United States, which can be seen in the re-emergence of limpet mine employment in May 2019 and the posturing of January 2020, has many MW specialists watching this region closely. In addition to its conventional mine stockpile, Iran has invested in unconventional weapons systems that challenge classic MW tactics. Its arsenal includes remotely piloted explosive-laden small craft, underwater swimmer-delivered charges, limpet mines and water-borne IEDs. The United Kingdom and the United States both maintain substantial forward deployed, though aging, MCM fleets in the region. Many Western-aligned Arab states like Saudi Arabia, Bahrain, the UAE and Qatar are also starting to invest in MW to protect their oil exports, although their forces are at present minimal.

Potential mining in the Strait of Hormuz.

This region also encompasses the third busiest SLOC, the Gulf of Aden and the Red Sea. Recent instability in North Africa and in Yemen has led to groups, like the Houthis, targeting shipping along this important maritime choke point. In addition to employing piracy tactics, we have seen these groups increasingly employing sophisticated unmanned explosive systems to raise the risk to shipping – thereby increasing shipping costs and threatening regional maritime security. Likely funded by state actors, the Houthis have successfully targeted this busy shipping lane with an array of water-borne IEDs including explosive-laden boats and improvised limpets. This hybrid use of conventional and unconventional MW tactics should cause Western powers to rethink the orientation of their MCM forces if they continue to be reliant on this region. Recent events in the Persian Gulf – the re-emergence of limpet mines and military tensions involving Iran in general – should serve as a wake-up call for both regionally invested maritime powers and onlookers alike.

The Baltic/North Seas

Both the North and Baltic Seas contain a large number of remnant mines from the First and Second World Wars. Many of NATO's MCM forces assemble there to continue the multinational effort to make these waters safe. The Danish Strait is the fourth busiest SLOC in the world. It serves as the main shipping route for oil to many European and Scandinavian countries and enables shipping and resource access to the North Sea for these states. The strait is dominated geographically by Denmark (NATO) and Sweden (non-NATO, though increasingly NATO friendly). The strait can be bypassed by the Kiel Canal, owned by Germany (also NATO). Russia maintains a large naval and commercial shipping presence out of its Baltic Sea port at St. Petersburg. Increasingly closed off in the Baltic by NATO powers, it is little wonder why Russia maintains a strong naval presence in the Baltic and why it exercises its naval forces routinely. It is also no wonder that Russia maintains the largest mine stockpile in the world. In addition to Russia maintaining substantial mine stocks in the Baltic, so too do many of the Baltic Sea states. NATO and non-NATO Baltic navies have recognized the effect that sea mines can have in the Baltic; even some states that, due to ethical concerns, consider mining to be abhorrent.

*The Danish minelayer **Falster** N80 lays mines near Eckernførde on the West German coast of the Baltic Sea, September 1983. The Danish navy was responsible not just for preventing the Soviet Baltic Fleet from moving into the North Sea, but also from conducting amphibious landings on NATO territory around the Danish Straits.*

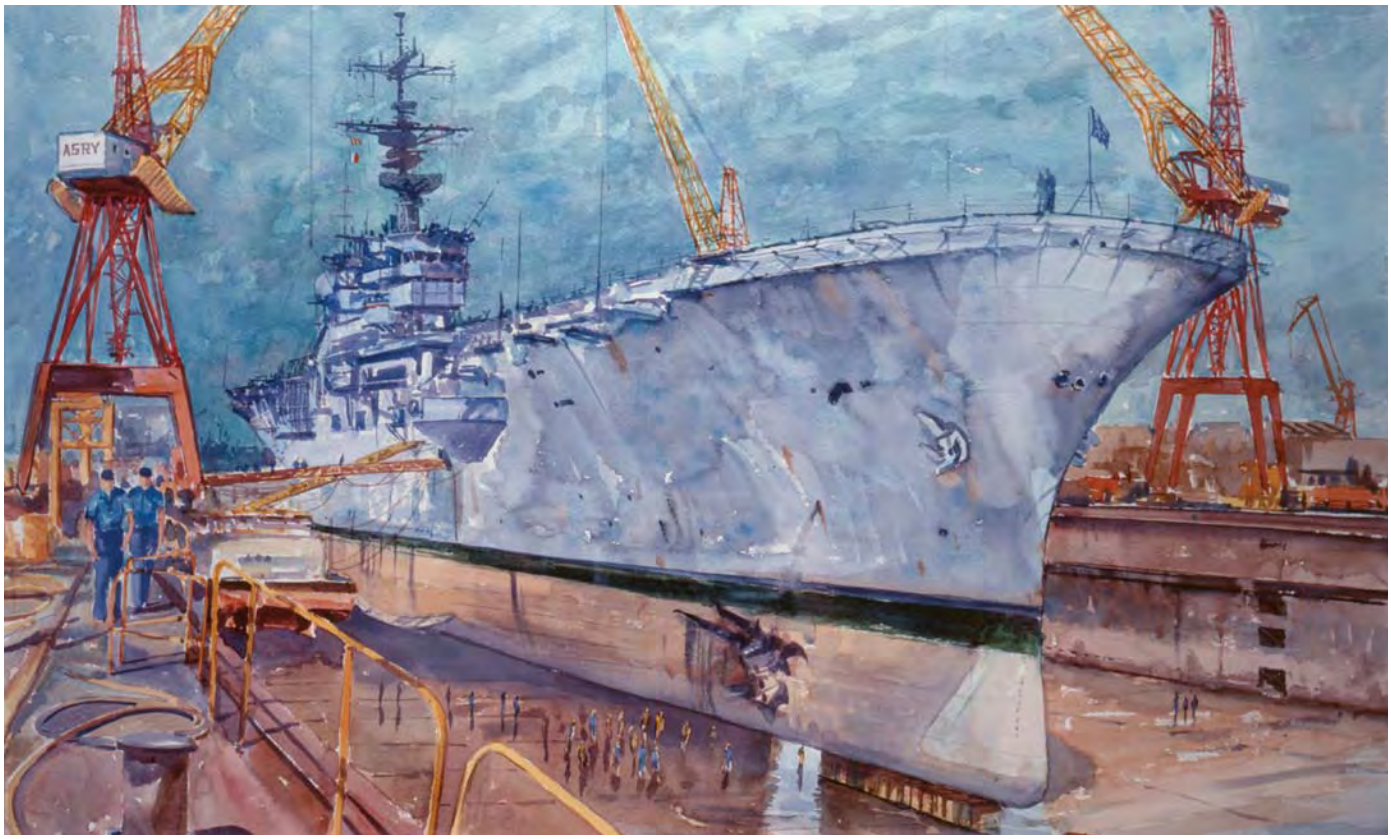
Conclusions

According to the Director General Naval Force Development in 2015, "[f]or the past century, the use of sea mines has been considered one of the greatest threats to maritime shipping, and sea mines are predicted to play a more prominent role in any future maritime conflict."[10] As noted, naval mines are a highly effective and relatively inexpensive tool of war at sea. Recent history and current events tell us that mines and associated unconventional naval tactics will either persist or be more prevalent in future naval conflicts. Yet despite all of this, many Western navies devote little of their attention and a fraction of their budgets on MW.

The Royal Canadian Navy (RCN) is, sadly, not immune to this, despite operating in many regions where the mine threat is very real. After the paying off if its *Bay*-class mine sweepers in 1998, Canada built the *Kingston*-class Maritime Coastal Defence Vessels to fill a variety of roles, including mine warfare. Despite being fitted for mine sweeping gear, and retrofitted to conduct towed side-scan sonar work (not in and of itself a MW task), being steel-hulled 'commercial-off-the-shelf' (COTS) construction, these vessels are unsuited for MW.

The only true MW asset the RCN possesses is a small number of clearance divers capable of small area search, location, identification, disposal and attribution of sea mines and IEDs. The RCN has also recently dipped its toe into the burgeoning realm of robotic MW systems by purchasing a very small number of shallow water autonomous side-scan sonar systems – the REMUS 100 autonomous underwater vehicle. These systems augment the clearance diving capability by enabling large area search, but their range, depth and overall number are limited. There is also a project underway to augment this system with a remote mine disposal system. The RCN does take measures to protect its fleet from the global mine threat including the acoustic ranging, degaussing and deperming of its larger ships. These are important steps to be sure, but lacking a robust MCM force and institutional knowledge, they lack credibility.

US naval analyst, H. Dwight Lyons attributes this lack of MW focus amongst Western navies to what he calls the "Vicious MCM Cycle."[11] According to Lyons, MCM gets attention when there is an incident, everyone discusses what should be done, then there is a budget discussion, memories of the incident fade, other projects are considered more important, and nothing gets done. Then another incident happens and the cycle is repeated. This keeps naval forces perpetually exposed to this dangerous and effective threat. The results can be catastrophic, yet apparently not catastrophic enough to address the problem. For example, USS *Samuel B. Roberts* struck an Iranian mine in 1988 during the Tanker Wars, USS *Princeton* and USS



Credit: Watercolour painting by John Charles Roach, via Naval History and Heritage Command

The amphibious assault ship USS ***Tripoli*** *LPH-10 receives repairs in drydock following a mine strike in the northern Persian Gulf while conducting minesweeping operations during* ***Operation Desert Storm*** *in 1991.*

Credit: MCpl Anthony Laviolette, Canadian Armed Forces

*Crew of the **Kingston**-class Maritime Coastal Defence Vessel HMCS **Shawinigan** and members of Fleet Diving Unit (Atlantic) prepare to use a REMUS underwater vehicle to locate practice mines outside Halifax Harbour, 23 March 2021.*

Tripoli both struck Iranian mines during the first Gulf War, and USS *Cole* was attacked by an al Qaeda water-borne IED whilst alongside in Aden in 2000. What results is a boom-and-bust cycle of NMW development. The lack of focus on MW in naval academies and naval strategy, too, contributes to the response to incidents being reactive rather than proactive in NMW.

Despite the lack of sustained focus on NMW, some navies have continued to push the envelope of technology and tactics. Some have made progress on unmanned mining systems, even employing them for atypical roles like targeting underwater resource extraction, pipelines or communications. We have also seen increased development of autonomous mobile mines and unmanned mine-hunting systems – this trend promises to continue. MCM technology, therefore, is trending away from purpose-built mine hunting/sweeping ships and towards largely autonomous over-the-horizon MCM payload systems. This enables navies without robust MCM fleets to invest in low-cost MCM systems which can be deployed on any vessel or even operated from ashore. Despite recent leaps in mine technology, though, MCM forces cannot yet forget traditional tactics. Until unmanned MCM technology progresses to the point of complete autonomy, can effectively connect with land forces and perform delicate render-safe procedures, divers will still be essential to fill this critical technology gap. Recently, the threat of old, but reliable, tactics has re-emerged targeting both commercial and military shipping with water-borne IEDs and limpet mines – further reinforcing the need for divers. These tactics will be used in future naval conflict in conjunction with conventional mining to exploit weaknesses of conventional naval forces.

In order to be prepared for this new MW reality, navies must first work to remove the stigma surrounding sea mines. Once admirals and strategists alike recognize mines, and NMW in general, as a viable and equally important facet of naval warfare, then states can make an honest unbiased assessment of their vulnerability to mines. In this way, navies can start to be proactive in their resolution of the mine problem, avoid the Vicious MCM Cycle and be ready to meet the asymmetric nature of future naval warfare.

Notes

1. "Naval Mine Warfare Vision"; NATO Naval Mine Warfare Centre of Excellence; *Naval Mine Warfare Principles,* MTP-06, Vol. 1, Ed. D., Ver. 3, NATO Standardization Office, 2019, p. 2-1, Art. 0201.
2. Milan N. Vego, *Naval Strategy and Operations in Narrow Seas* (New York: Frank Cass Publishers, 1999), "Chapter 2: The Factor of Space," p. 48.
3. United States Navy Fact File, "Harpoon Missile," 10 May 2017, US Navy, available at https://www.navy.mil/Resources/Fact-Files/Display-FactFiles/Article/2168358/harpoon-missile.
4. Federation of American Scientists Military Analysis Network, "Mk-48 Torpedo," 12 December 1998, Federation of American Scientists online, available at https://fas.org/man/dod-101/sys/ship/weaps/mk-48.htm.
5. David A. Morris, "The Mine Warfare Cycle: History, Indications, and Future," GlobalSecurity.org, 1997.
6. Scott C. Truver, "Taking Mines Seriously: Mine Warfare in China's Near Seas," *US Naval War College Review*, Vol. 65, No. 2 (Spring 2012), p. 32.
7. US General Accounting Office, Report, "Navy Mine Warfare: Budget Realignment can Help Improve Countermine Capabilities," March 1996, US Government Accounting Office.
8. As Asian economies grow, the importance of this strait cannot be overstated. Some estimates indicate that any prolonged closure of the strait would raise shipping rates by as much as five times present levels. Vego, *Naval Strategy and Operations in Narrow Seas,* pp. 39-40.
9. Bernard D. Cole, *Sea Lanes and Pipelines: Energy Security in Asia* (Westport, Connecticut: Greenwood Publishing Group, 2008), pp. 85-89.
10. Director General Naval Force Development (DGNFD), "Concept for Naval Mine Countermeasures," RCN DGNFD, November 2015, p. 2; Truver, "Taking Mines Seriously."
11. H. Dwight Lyons Jr. et al, *The Mine Threat: Show Stoppers or Speed Bumps?* (Alexandria, VA: Center for Naval Analyses, 1993), p. 28.

Lieutenant (N) Sebastian Harper is an RCN Clearance Diving Officer serving in Esquimalt, BC and has recently completed his Master of Arts in War in the Modern World at King's College London. This article is an excerpt from his MA dissertation entitled: "The Science of Vague Assumptions: Naval Mine Warfare and the Future of Naval War," 23 March 2020.

Modernizing Anti-Submarine Warfare: A Systematic Journey

Commander Chris M. Devita

Over the past two decades, submarine proliferation has been steadily increasing, with over 100 boats being added to the worldwide inventory over the past decade – a number which continues to climb steadily. Both open source and classified intelligence confirms this fact. A simple google search will confirm that the number of different states using submarines is increasing.[1] One does not need to look very hard to find information on new submarines being built[2] or being used.[3] Institutional actors, both government state and non-state (such as drug cartels), have increased both the number and capability of their submarines.[4]

In general, the submarines in use today are more sophisticated and their torpedoes more capable than ever before. Of the 41 submarine-capable countries today, six have some form of nuclear-powered submarine – China, France, India, Russia, the United Kingdom and the United States – capable of staying submerged longer than earlier versions and running under Arctic ice.

Semi-submersibles and autonomous systems are now part of the underwater battle space, in addition to a number of systems such as gliders or unmanned remote vehicles. Even narcotics smugglers are using semi-submersibles to transport their goods from South America to destinations in the United States and Europe via the Caribbean and the Pacific. Over the past decade, the air independent propulsion systems (systems that do not require fresh air exchange to recharge batteries) that were once considered a specialized tool are now commonplace.[5] Torpedoes are getting faster, smarter and more effective, and in some cases combine technologies that increase targeting accuracy and lethality, making traditional decoys much less effective.

In addition to the changes in platform and weapons threat, the environment is changing as well. The melting of Arctic ice and rising sea levels have made traditional knowledge of the oceans less reliable as salinity and temperatures change in certain areas. Activities in littoral regions that were once not possible for submarines are now potentially possible because of increases in depth and changed water conditions (such as visibility, currents and temperature changes). In some ways, the potential threat from submarines is more significant now than it was during the Cold War as the number of submarines and states using them has changed, just as the physical environment has changed.

Credit: Mass Communication Specialist Elizabeth Merriam, US Navy

A US Navy MH-60S Seahawk helicopter prepares to evacuate a medical casualty from the Republic of Korea diesel-electric submarine ***Lee Eok Gi*** *SS 071 on 26 May 2016 in the Pacific Ocean.*

In order to deter and counter this new and emerging threat, the Canadian Armed Forces (CAF) has embarked on an incremental and phased approach to improving anti-submarine warfare (ASW) readiness. Starting at long range with maritime patrol aircraft upgrades, moving closer to the task groups with new maritime helicopters, and finally in-close with upgrading the *Halifax*-class ASW suite, many improvements have been made, with more to come. Underpinning these enhancements, which are the result of a systematic and layered approach undertaken by the CAF over the last decade, is the updating and operationalization of the *Victoria*-class submarines.

The CAF is systematically upgrading its ability to respond under water in several ways. It is doing so by updating equipment, gaining a better understanding of the battle space, using science and technology (S&T) programs within the Department of National Defence (DND) that will enable the CAF to remain effective into the future, and leveraging both knowledge and equipment from allies and industry to meet this challenge. To the CAF, time and space actually have multiple meanings. Time often refers to the years that are needed to conceive, design, build and implement a major Crown capital project but in the case of ASW, it also refers to the response time

The first Block IV-upgraded CP-140 Aurora is seen here during initial flight tests of the upgraded airframe in February 2020.

required to make a decision about whether to fire a torpedo. Space refers to the geography in which operations take place, both in a specific location on the planet from the ocean floor up to space, but also to the conceptual and physical distances and defensive parameters around the object to be protected. Creating time (the time available to respond) and space (the distance at which threats can be identified) is ultimately what good ASW does in order to 'deny the enemy effective use of their submarines' as my old instructor used to say. By creating more time and space, better decisions can be made. The CAF has taken a long-term view to modifying its forces to adjust to this growing threat environment.

What is the CAF Doing Now?

The CAF has a longstanding history with ASW. While the attention to this issue has waxed and waned with the times, it has always been an area of practice. If you wish to counter a submarine, you must understand both the environment and the tools the enemy submarine has versus the tools you have. These tools can include both acoustic and non-acoustic sensors, the ranges at which you may need to operate from a known threat, and understanding of the desired end goal the mission commander needs to achieve. To accomplish this goal, you must use all manner of assets, intelligence and knowledge of the battle space – and occasionally have good luck. In Canada's case, the CAF began to update the ASW force over a decade ago.

The CP-140 Aurora Long-Range Patrol Aircraft has undergone a series of modernizations that have improved ASW capability. The aircraft represents an outer long-range defence ring around a naval task group, a convoy of merchant ships, or even the country itself. Canada embarked on a CP-140 upgrade program in a series of blocks. Blocks I-III are now completed and the final block IV upgrade package has commenced, which builds on the other three components. Specific to ASW in these upgrades was the replacement of mission computers (the system processors for sensor and flight data) and sensors including radar, electronic support measures, electro-optical sensors, infra-red sensors, magnetic anomaly detectors and acoustic detection systems. The final block will improve CP-140 self-defence and communications, including enhancements of satellite communication systems and a Link 16 military tactical data link network, which will enable better battle space awareness and mission execution. All of these upgrades are inside a proven airframe that has also undergone a life extension refit program.

In the future, Canada will be acquiring a NATO-compatible new Canadian Multi-Mission Aircraft (CMMA) to replace the CP-140. The aircraft will not only deliver the latest in traditional ASW tools, but will also take advantage of new technology in an ever-growing system of systems that will include artificial intelligence, data fusion, scalable autonomy, electronic warfare, improved communications and new weapons that will give the airframe both torpedoes and missiles to help with both sub-surface and surface battle spaces. Project work on the new aircraft has already started.

The Maritime Helicopter Program (MHP) provides the platform that operates one layer closer to the task group.

The Sea King helicopter has now been replaced by the Cyclone helicopter. The Cyclone has a number of key advantages over the previous helicopter, including a new dipping sonar. The sonar, an L-3 HELRAS Low Frequency Active (LFA) sonar system, is an important ASW enabler. The LFA has given the helicopter a significant range advantage from a few hundred yards to thousands of yards in detection ability. The Cyclone has an Integrated Mission System developed by General Dynamics Canada which is coupled with the improved Sonobuoy Acoustic Processing System, giving the Cyclone a potent advantage over the Sea King. In addition to radar, it has both an electro-optic system and a forward-looking infra-red system, as well as electronic support measures sensors to assist with the non-acoustic detection of submarines. Non-acoustic detection involves systems that are not sonar-related like electronic listening for radar or radio communications, radar to detect periscopes, magnetic anomaly detection, and electro-optical (visual) methods. The Cyclone is equipped with defensive countermeasures, such as flares for example, to protect itself against anti-air missiles.

The Underwater Warfare Suite Upgrade (UWSU) is the program that addresses modernizing the close-in layer of ASW. UWSU upgrades the current hull-mounted sonar and sonobuoy processors on the *Halifax*-class frigates and includes a towed array that has both an LFA and a passive capability. These sensors, combined with new and better processors, will enhance Canada's *Halifax*-class, enabling the ships to meet and beat current threats. More importantly, the UWSU upgrade has the elements that provide the technical building blocks for the future, in addition to maintaining and advancing sailor knowledge as the CAF and the Royal Canadian Navy (RCN) bridge the transition to the new Canadian Surface Combatant. The technology bridge has proven in the past to be important for sailor skill sets, and is no different now. The technology building from old to new blocks will enable Canada to have a more advanced system in the future, and will keep up with the enemy.

The weapons system (referred to as the 'effector') will soon change as well. Deterring a threat is an important first line of defence, but detecting the threat is the next line. Being able to detect the threat is, however, only part of the story. Knowing a sub-surface threat exists in the area is part of the solution to the problem, but being able to deal with it is the end goal. Limiting the enemy's ability to employ its submarines effectively is the ultimate goal of ASW. Effective detection and tracking can do this, especially if you can localize the submarine to a specific position, but to have any lasting effect the submarine must be severely damaged or destroyed. The CAF is in the process now of upgrading both light-weight and heavy-weight torpedoes. It has begun purchasing new Mk 54 torpedo upgrade kits to update the Mk 46 Mod 5 inventory to modern standards. A number of NATO partners are also in the process of acquiring this torpedo. The new Mk 54 torpedo kits will enhance Canada's light-weight torpedoes across all three platforms (ships, helicopters and fixed-wing aircraft), providing a new and upgradable torpedo in the Canadian inventory for the next two decades. The first of the new torpedoes is scheduled to start coming online in the mid-2020s, more or less matching the integration of the new weapon into the *Halifax*-class ships, Cyclone helicopters and Aurora fixed-wing platforms, and on the heels of the first UWSU installation.

New torpedoes will enhance ASW but the best ASW defence is your own submarine. Canada's submarine upgrade program is also under way. Canada's *Victoria*-class submarines are a key element in the system-of-systems approach to maritime domain awareness and ASW. Working together with surface and air surveillance capabilities, they play an important role in sovereignty operations and continental defence. The *Victoria*-class submarines will undergo incremental modernization in the mid-2020s, which will ensure their continued effectiveness to the mid-2030s. In addition to the modernization, a new heavy-weight torpedo is also being purchased. The new Mk 48 7AT will give Canada more underwater combat power to deal with both hostile surface and submarine threats.

RCAF Airborne Electronic Sensor Operators, Warrant Officers Darren Struble and Chuck Paquette, prepare sonobuoys onboard a CP-140M Aurora while in Hawaii during RIMPAC 2014.

Credit: MCpl Manuela Berger, Formation Imaging Services Halifax

Raptor, the CH-148 Cyclone helicopter from HMCS ***Toronto****, lowers its Helicopter Long Range Active Sonar (HELRAS) during* ***Operation Reassurance*** *in the Mediterranean Sea, 9 June 2019.*

Much of Canadian security is predicated on deterring threats to North America, and submarines are a part of the deterrent. The very presence of Canadian submarines in our sovereign waters, coupled with a strong ASW capacity, can deter an adversary. As the saying amongst submariners goes: the best way to find a submarine is with another submarine, and the best way to deter an adversary submarine is with your own.

The Future

Canada has a dedicated science and technology ASW program that is seeking to advance our knowledge in all areas of ASW. This includes autonomous underwater vehicles (AUVs) and acoustics to examine how best to use LFA sonars and multi-static sensors. A multi-static sonar system is made up of "a combination of sonar sensors (either active or passive) placed at different locations. As the type of platforms and their numbers are variable, configurations are multiple: a multi-static sonar can include an active sonar (a hull-mounted or towed source in a frigate), a passive array towed by another ship or an autonomous underwater vehicle, an array of sonobuoys and another array of moored hydrophones, becoming a real sensor network."[6] This will allow multiple acoustic receivers to help process data from a single ping source to track and localize sub-surface targets. Integrated torpedo defence and other counter-torpedo methods are being examined to increase ship survival.

Most importantly, there is work being done on the fusion of information on all manner of things under water into an underwater battle space decision tool that will allow rapid assimilation of information, environmental data sensor inputs and intelligence, which will be the key to success in a complex operating environment. Data fusion, machine learning and artificial intelligence are all part of "The Concept for ASW," which is a series of ideas about how to deal with ASW in the future, and are encapsulated in the RCN's science and technology program. Leading-edge projects like ATRIUM and CRACCEN are designed to transform how ASW is done. ATRIUM is a program focused on integrated torpedo defence that is examining the detect-to-engage sequences needed to launch an anti-torpedo torpedo. CRACCEN is the program that is conducting work on data fusion and decision aids for ASW mission planning and execution. The science and technology programs are mated with the current and future upgrade programs to ensure a harmony of effort. While a series of incremental steps have been taken, a number of these small steps together build into enabling technology that will lead to transformational ASW technologies.

The question of how best to use AUVs and other autonomous systems is also being examined. The autonomous systems have a host of potential applications. For example, DND's Atlantic Research Centre has already acquired some AUVs and is exploring how best to employ these tools in areas of naval mine warfare, and also how they can be potentially used in the Arctic to survey, map and study the environment by measuring water temperature, salinity, currents and other climatic and meteorological effects. Work on how the CAF can better monitor and patrol the Arctic area and, if necessary, respond decisively to a submarine threat, is also being examined. Currently,

work is under way to experiment with some new capabilities aboard HMCS *Harry DeWolf* during its first Arctic exercise (*Operation Nanook*) likely with containerized acoustic arrays. The knowledge gained from this activity will help form the statement of requirements for future projects.

While equipment in the ship can be upgraded or modernized, it is not optimized until sailors assume their stations. The sailor is the most important system in the ship. All of the current upgrades and science and technology programs are seeking to help manage the sailor's work load so that he or she can make better and faster decisions. All the new systems are seeking to enable sailors and aviators to make the greatest impact. The training needs of the operator are already being examined and mapped so that when the new equipment arrives, the operators are better able to use them effectively. The technologies being installed now will lay the foundation for the skills Canadian sailors will need later. These skill sets are a valuable resource in ASW, and need to be regularly maintained and updated.

Conclusion

There has been much discussion about what the CAF can do to meet the submarine threat of the future, and if what the CAF is doing now is correctly structured or will matter over the long haul. The CAF has already started a dedicated effort to modernize, upgrade and ultimately transform its ASW capability. This plan started years ago and will continue for years to come. The CAF is working on long, medium and short ranges around the task group concept with sensors, both acoustic and non-acoustic, across multiple platforms.

The plan is designed to give commanders and operators more time to make better decisions. Coupled with the ASW sensors is a dedicated torpedo upgrade program across multiple platforms including air, surface and sub-surface. These upgrades not only allow the CAF to remain a credible fighting force, but enable future programs to transform Canada's ASW capability over the next 15 to 20 years.

Lastly, the technologies that are being worked on now will allow for integration into future platforms such as the Canadian Surface Combatant and the Canadian Multi-Mission Aircraft. NATO is also working with member states on standards and best practices for low-frequency active sonars which are now viewed as the way of the future and in which Canada is playing a part. Ultimately, good ASW is the harmonization of a system of systems, which is what the CAF has done, is doing and will continue to do in the future.


Credit: David Malysheff, DND

Petty Officer 2nd Class David Johnson, a Senior Weapons Technician and Torpedo Instructor, prepares a reusable exercise version of the Mk 48 heavyweight torpedo on HMCS ***Victoria****, 13 March 2012, at the Nanoose Bay test range.*

Notes

1. Nuclear Threat Initiative, Submarine Proliferation Resource Collection, 16 December 2020, available at https://www.nti.org/analysis/reports/submarine-proliferation-overview/.
2. Ministry of Defence, Singapore, update 1 June 2016, available at https://www.mindef.gov.sg/web/portal/pioneer/article/regular-article-detail/ops-and-training/2018-dm/01Jun2016_01180.
3. Mark Romanow, "Submarine-Proliferation and Canada's Need for Nuclear Powered Submarines," *FrontLine Defence*, Vol. 13, No. 4 (2016).
4. Jan Joel Andersson, "The Race to the Bottom: Submarine Proliferation and International Security," *US Naval War College Review*, Vol. 68, No. 1 (2015).
5. Kyle Mizokami, "AIP Submarines: The Warship of the Future?" *The National Interest*, 18 March 2021.
6. Multistatics is emerging technology into which both NATO and Canada are looking. For more information, consult the Centre for Maritime Research and Experimentation (CMRE), part NATO's Science and Technology wing. See CMRE, NATO, "The Multistatic Sonar Systems," 22 August 2018.

Commander Chris M. Devita, RCN, is the UWW Section Head in the Directorate of Naval Requirements in the Naval Staff in Ottawa.

Artificial Intelligence: How Can the RCN Benefit in the Near Term?

Megan Martins Da Ponte

Technological change has long played a transformative role in naval operations, affecting both platforms and weapon systems. As society enters the 'Fourth Industrial Revolution' (4IR), states have shifted their attention to the development of Artificial Intelligence (AI) applications for use within the military sphere.[1] As of February 2020, 50 countries have published or announced the development of an official AI strategy, with Canada releasing its in March 2017.[2] As such, AI can be understood as an instrument of international competition and national security, which brings into question the relationship between AI and middle powers such as Canada in the context of the 4IR.

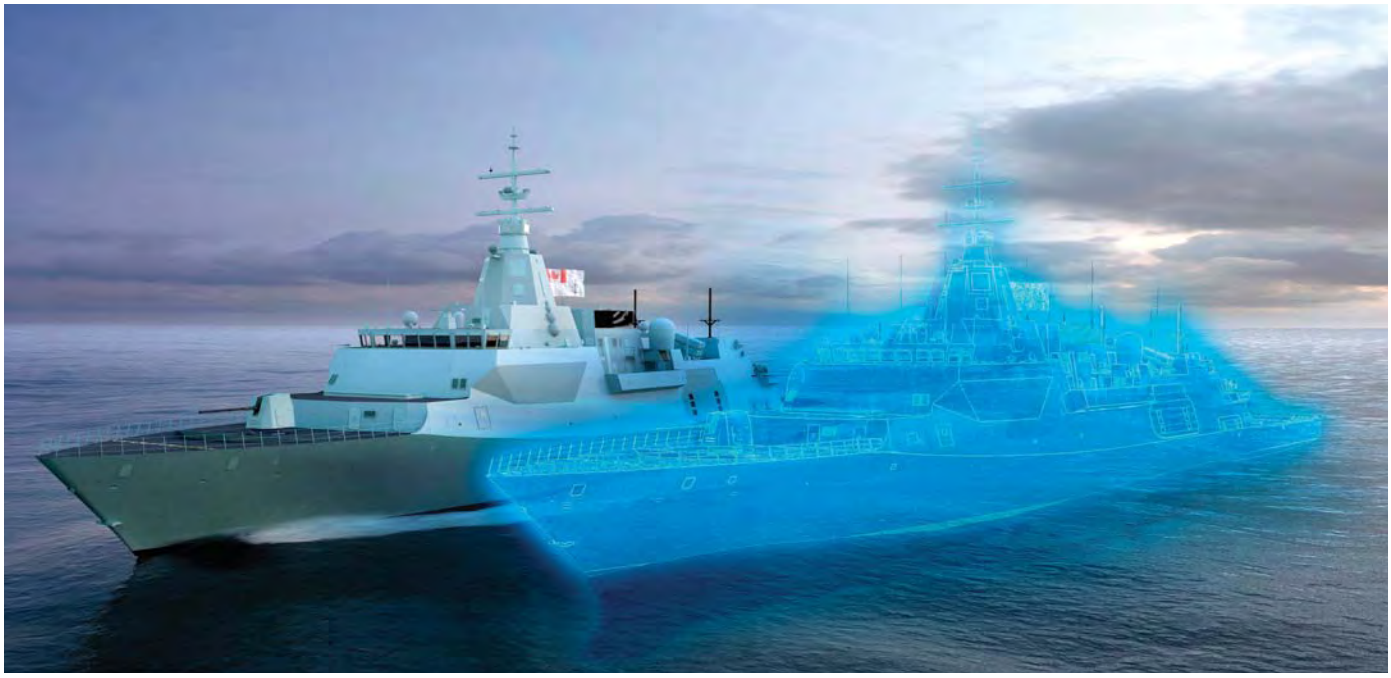
Much of the current literature on military applications of AI focuses on the ethical and security implications of reducing human oversight from the decision-making process in combat. However, the sophistication required to produce that level of autonomy is beyond the scope of current AI technology. This does not mean that the Royal Canadian Navy (RCN) cannot benefit from the implementation of AI in the near term; it can. For now, AI should not be understood as a weapon, but rather as a force multiplier within the RCN.

The Canadian maritime domain features the world's longest coastline, the second largest continental shelf, and the fifth largest Exclusive Economic Zone (EEZ) in the world.[3] But despite its large geography, Canada has a small population and a relatively small economy. In an era of renewed great power competition, the RCN faces challenges to its operational capability due to the small size of the RCN and to personnel shortages, which range from 10-40% depending on the specific area, and hinder Canada's ability to maintain awareness within such a large area of responsibility.[4] The RCN must shift its attention to the integration of enabling technologies to enhance its current force structure and bridge capability gaps in the near term.

It is critical to understand the possibilities and limits of AI technology to identify areas that will best advantage the RCN and satisfy the objectives laid out within the Digital Navy Initiative.[5] This article will define Artificial Intelligence, examine how AI can benefit naval logistics and address the vulnerabilities linked to this technology.

What is Artificial Intelligence?

Before we discuss the utility of AI to the RCN, we must first define it. Broadly defined, AI is the ability of machines to perform tasks which normally require human intelligence.[6] Although this technology has potential and current uses across commercial, civil and military sectors, it is important to differentiate among the types of AI in order to understand how this technology can be implemented into maritime strategy.



Credit: BAE Systems Canada

An illustration of the Canadian Surface Combatant alongside its 'digital twin' used to proof concepts virtually before they are implemented in the physical world.

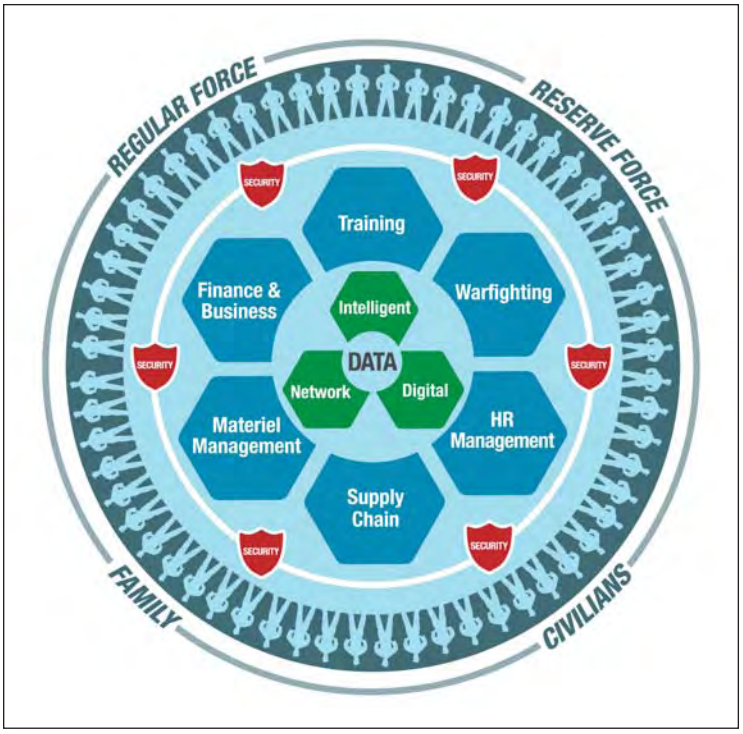
Artificial Narrow Intelligence (ANI), also known as 'weak' AI, refers to machine intelligence that *equals or exceeds* human intelligence for *specific* tasks.[7] Narrow AI operates within a pre-determined, pre-defined range and lacks the self-awareness, consciousness and genuine intelligence to match human beings.[8] The machine intelligence with which we are currently familiar is comprised of ANI technology – for example, Siri, Alexa and Google Maps.

Artificial General Intelligence (AGI), or 'strong' AI, refers to machine intelligence *meeting the full range* of human performance across *any* task.[9] AGI would have the ability to reason, solve problems, make judgements under uncertainty, strategize and think abstractly. However, at this time AGI only exists within the realm of science fiction – think HAL 9000 from the movie "2001 Space Odyssey," or TARS from "Interstellar." Going one step further is Artificial Super Intelligence (ASI), defined as an "intellect that is much smarter than the best human brains in practically every field, including scientific creativity, general wisdom and social skills."[10] Alarmist rhetoric concerning the ability for AI to take over the world are based upon this as yet entirely hypothetical conceptualization of AI.

The dominant AI paradigm since the 2010s has been deep learning or deep neural networks. Deep learning is one method among many within the field of machine learning, which is a sub-field of AI, in which machines 'learn' from data, or their own 'experiences.'[11] Other methods of AI require coding practices with complex rules and decision-trees, whereas machine learning involves feeding large amounts of data into an algorithm and allowing for self-adjustment and improvement as the data is assessed.[12] Deep learning procedures fall into one of three categories: supervised, unsupervised and reinforced.

Supervised learning methods involve the gradual adjustment of parameters through the repetitive processing of examples in a training set in order to learn the classification of each input as one of a fixed set of possible output categories.[13] The 'supervision' aspect necessitates informing the system about the classification of each datum in the training set.[14] This method produces highly accurate results due to the specific labeling of data, however, this also increases the time and complexity associated with training the algorithm. Additionally, supervised learning has limited flexibility as it is unable to learn on its own.

In contrast, unsupervised learning refers to a broad array of methodologies for learning categories or actions without labeled data. Examples of this typology include methods for clustering examples based on their similarities or learning a new category via analogy to recognized categories.[15] This method is able to identify patterns from large amounts of data that would be difficult for a human operator but often at the expense of accuracy and



Credit: Royal Canadian Navy

Figure 2.2 from the RCN's Digital Navy Initiative document shows the framework within which the initiative will take place.

explainability – without specific labels, it is difficult to confirm any results.

At the middle of the spectrum, is reinforcement learning. Reinforcement learning is based on trial-and-error. This procedure requires no labeled training examples, instead the learning program performs actions in an environment, receiving occasional corrective input.[16] As this method learns through interacting with its environment, it is both data and time intensive. However, this method is often able to outperform humans as it learns and corrects errors through the training process. One example of this is Google's AlphaGo Zero which was able to outplay humans and its predecessor (AlphaGo) in the game of Go after only three days of self-play training.[17]

It is already becoming clear that AI can perform in a manner that is cheaper, faster and more consistent than human intelligence. Algorithms can be trained to complete specific, anticipated tasks with predictable and describable rules.

Application of AI to Naval Logistics

Based on the likelihood that algorithms will improve faster than any sailor could, the RCN needs to identify tasks involving repetitive and manually intensive training for AI integration to reduce constraints on manpower.

One key area in which the RCN should focus on integrating AI technologies is operational planning and training. The nature of the maritime domain presents a unique logistical challenge as ships are limited in their carrying capacity. The ability to make decisions regarding matters such as supply, communications and transport requires

sifting through large amounts of data from multiple sources. Typically, decision-makers in this context will examine previously made choices within a similar framework. Through a centralized database and algorithms, AI could increase the speed and efficiency of naval planning and logistics by supplementing the human cognitive process and eliminating issues stemming from human error and miscommunication. This analysis will examine two specific areas that are suited for AI integration within the near term and could contribute to enhancing operational readiness in the RCN – predictive analytics and maintenance/training.

Predictive Analytics

Predictive analytic processes use historical data to predict future events, typically through building a mathematical model that captures important trends.[18] By definition, this does not necessarily require either AI or machine learning. However, the complexity of predictive analytics increases with data size representing a serious challenge to navies. The USN collects approximately 200 terabytes of data every day through numerous manned and unmanned sensors making the effective identification of key information and patterns required for accurate decision-making an impossible task for human operators.[19] The RCN is much smaller than the USN but it still collects significant amounts of data. The data overload currently experienced by navies has increased the demand for AI-powered predictive analytics to amalgamate, sort and analyse data from various sources.

The application of AI to predictive analysis is already in the initial stages of implementation within US naval operations. The USN Military Sealift Command (MSC) has recently contracted Abeyon, an AI company, to create the means to move from a preventative, condition monitoring-based maintenance approach to a proactive, reliability-based approach. Abeyon has created an AI-powered analytics tool, Clarifi, which will allow the MSC to derive meaning, gain insights, identify trends and extract valuable knowledge from years of unstructured data.[20] Previously, maintenance and repairs on ship machinery were completed through work order, voyage repair requests and other document formats. This has evolved through emerging technologies, forming an integral part of MSC operations to perform effective management and maintenance of USN vessels. Despite efforts to document work performed electronically, human error has led to inconsistencies within the logging process. Consequently, information regarding the comprehensive histories of machinery would be lost, meaning that it could not be applied to the strategic decision-making process.[21]

Approximately 30% of repair data within the current system lacks records of the specific equipment information. In efforts to recover the missing information MSC has had to assign engineers to review each document and identify the relevant domain information. This labour-intensive process has been detrimental to the efficiency of MSC, greatly reducing its functional capacity in respect to its role within the USN. In efforts to ameliorate the negative effects of data inconsistencies, MSC N7 Engineering tried to identify solutions that could learn and extract domain knowledge through integrating the unstructured documents using AI and machine learning. This effort was supported by Abeyon which reviewed and annotated sample documents that were representative of the larger unstructured dataset.[22] Through utilizing the sample dataset, the Abeyon team then built a machine learning model that could automatically analyze unstructured data as well as identify entities, relationships between equipment data and other important data.[23] The machine learning model was 'trained' in an iterative manner, exemplifying reinforced learning procedures.

The goal of the Clarifi analytics tool is to "identify equipment, associated technical specs, and other valuable information … to enable MSC to have complete visibility into a large set of unstructured data."[24] Although it is still in its initial stages of learning, this enhances the efficiency

Credit: Jennifer Hunt, US Navy

The US Military Sealift Command vessels USNS ***Mendonca*** *(T-AKR 303), USNS* ***PFC Eugene A. Obregon*** *(T-AK 3006), and USNS* ***Gilliland*** *(T-AKR 298) are seen here sailing during a no-notice 'Turbo Activation' exercise on 24 September 2019 to test the readiness of the US sealift forces.*

Credit: MCpl Andre Maillet, MARPAC Imaging Services

*HMCS **Ville de Quebec** conducts a replenishment at sea with the Spanish supply ship **Cantabria** while underway in the Atlantic Ocean, 14 November 2018.*

and reliability of the decision-making process. It is important to understand, however, that this technology does not represent a quick fix. A stress test of the US sealift fleet demonstrated the need for greater integration of AI with actual maintenance practices.[25] Nonetheless, this technology establishes important groundwork for further AI implementation and provides an example from which the RCN can learn.

Maintenance and Training

Canada has also made significant first steps towards incorporating AI into the field of naval maintenance and training. The RCN has been testing a Mixed Reality Remote Assistant Support (MiRRAS) system based upon Kognitiv Spark's software for the Microsoft HoloLens which utilizes augmented reality, mixed reality and AI integration to enhance the efficiency of ship operations – including repairs, maintenance and training. This system allows an expert from anywhere in the world to see through the eyes of the HoloLens wearer and provide guidance using real-time voice and video, interactive holograms and live data. This software also provides locally stored data to assist in the event that a remote expert is unavailable. Overall, this software has been designed to improve decision-making by reducing errors and facilitating decisive action.[26]

The 3D interactive content offered by this technology is more easily interpreted than paper manuals. This decreases mental fatigue of crew members and presents a major advantage under harsh and stressful conditions.[27] Additionally, the novelty associated with new, innovative technologies, such as Kognitiv Spark's MiRRAS, could boost RCN recruitment through appealing to the younger 'wireless' generation. As such, Project MiRRAS creates numerous opportunities within the RCN such as reducing operational downtime, enhancing knowledge transfer and decreasing the cognitive burden for crew members – which in turn can alleviate strain caused by personnel shortages within the RCN.

Challenges and Vulnerabilities

AI technology can be a significant force multiplier and enhance operational efficiency. However, the inherent advantages of AI technologies are not without accompanying vulnerabilities. A 2018 Pew Research Center study outlined the following major concerns about the long-term impact of AI on humankind: loss of human agency; dependence lock-in; and data abuse.[28]

Concerns regarding the loss of human agency emphasize the dangers associated with the reduction, or loss of human input. This becomes a serious area of contention within the context of military innovation due to the complexities surrounding autonomous weaponry and accountability. However, within the near-term applications of AI, concerns should be directed at challenges arising from the explainability and trust of AI systems. The opaqueness of complex deep neural network (DNN) algorithmic layers within AI processes limits human understanding, and therefore impedes trust.[29] This problem is exacerbated by the unknown variables which drive the human deliberative process – such as human instinct or unconscious biases. To ensure trust and accountability of AI applications, the RCN must emphasize algorithm transparency and develop strategies both to identify and mitigate bias in AI systems.[30]

A second prominent area of concern is dependence lock-in. The advantages to offset issues linked to functional capacity such as personnel shortages may be nullified in the event of an attack on AI systems. As discussed earlier, the tasks best suited for AI integration are repetitive and training intensive – either falling into the category of rule-based or skill-based tasks. Although these tasks are not associated with high levels of complexity for human operators, an increased reliance on technology may limit human resilience. This refers to the possibility of human operators either forgetting how to do the task or completing the task inefficiently due to slow processing and data overload. A learned task can be easily forgotten without consistent training.

Technological dependence is already an issue experienced within society. Reliance on technology may produce sub-optimal levels of efficiency in the event of a crisis or a disruption. This could become a life or death matter at sea. The solution to this would be to maintain a degree of human oversight through the applications of AI into naval force structure and holding frequent military exercises to ensure the crew is able to function in the event of a disruptive attack. Emphasizing crew resilience in the information age will be necessary for avoiding technological dependence and for continued combat readiness at sea.

The third, and arguably the most critical, challenge of AI integration within the near term concerns vulnerabilities linked to digital security. As defined earlier, current AI applications involve algorithms which are trained to complete specific tasks with describable and predictable rules. This means that AI can identify correlations within data but lacks the cognition to 'think' on its own. Furthermore, DNNs are vulnerable to adversarial data inputs, or 'spoofing attacks,' that may not be readily observed by humans.[31] Studies have demonstrated this threat through adding synthetic inputs to force a particular DNN to misclassify an image of a stop sign as a yield sign illustrating the possibility of a black-box attack against DNN classifiers by adversaries. This presents a serious issue within the context of naval operations; misidentification of imagery could inadvertently escalate tensions or sabotage vessel repairs/maintenance, which could have disastrous consequences in a harsh environment such as the high seas.

Conclusion

The application of AI to naval planning and maintenance has the potential to enhance the RCN's operational capabilities within the near term. However, until the inherent vulnerabilities of deep learning methods are better understood, there needs to be a high degree of human oversight for the advantages to come into fruition. The field of logistics is an area that can be enhanced by the gains provided by AI technology. AI integration should be encouraged but approached with caution to mitigate the new challenges and vulnerabilities linked to 'smart' technology.

Credit: MCpl Ryan Winton

Leading Seaman Chris Richards checks circuit boards on HMCS ***Toronto*** *while using Kognitiv Spark/Microsoft Hololens mixed reality goggles on 11 September 2019, in Halifax.*

Credit: MCpl Andre Maillet, MARPAC Imaging Services

Lieutenant (N) E. Roberts points out Jupiter to Sub-Lieutenants Sophie Cormier and Thomas Conrad during celestial navigation training with sextants on HMCS ***Ville de Quebec*** *in the Mediterranean in 2018. Traditional seafaring skills are being maintained to avoid an overdependency on digital navigational methods.*

The enabling features of AI will increase the RCN's logistical efficiency through optimizing data analytics while reducing strain on RCN personnel. Furthermore, the RCN could close the existing capability gap through leadership in AI innovation – towards which it has been making fundamental progress. The RCN should continue to develop AI technologies for logistics and military planning and training to optimize resource allocation. This will pave the way for an increased technological culture within naval force structure, which will be necessary for future innovation. The next revolution in military affairs may be in the distant future, but we must be ready for it when it arrives by pursuing integration of AI technology in the near term.

Notes

1. The conceptualization of the Fourth Industrial Revolution was first introduced by Klaus Schwab in 2015 to describe future societal transformation due to emerging digital technologies. See Klaus Schwab, *The Fourth Industrial Revolution* (New York: Crown Business, 2016).
2. "National and International AI Strategies," Future of Life Institute, last updated February 2020, available at https://futureoflife.org/national-international-ai-strategies/.
3. Government of Canada, *Strong, Secure, Engaged: Canada's Defence Policy* (Ottawa: Minister of National Defence, 2017), p. 34.
4. Lee Berthiaume, "Sailor Shortage Causing Headaches for Royal Canadian Navy," *CTV News*, 14 February 2019.
5. See Department of National Defence, *Digital Navy: A Strategy to Enable Canada's Naval Team for the Digital Age* (Ottawa: National Defence, 2020).
6. United States, Department of Defense, *Summary of the 2018 Department of Defense Artificial Intelligence Strategy* (2018), p. 5.
7. Stephan De Spiegeleire, Matthijs Maas and Tim Sweijs, *Artificial Intelligence and the Future of Defense* (The Hague: The Hague Centre for Strategic Studies, 2017), p. 12.
8. Tannya Jalal, "Distinguishing between Narrow AI, General AI and Super AI," *Medium,* 21 May 2018.
9. Spiegeleire, Maas and Sweijs, *Artificial Intelligence and the Future of Defense*, p. 12.
10. Nick Bostrom, "How Long Before Superintelligence?" *Linguistic and Philosophical Investigations*, Vol. 5, No. 1 (1998), p. 11.
11. Melanie Mitchell, *Artificial Intelligence* (New York: Farrar, Straus and Giroux, 2019), p. 21.
12. Calum McClelland, "The Difference Between Artificial Intelligence, Machine Learning, and Deep Learning," *Medium*, 4 December 2017.
13. Mitchell, *Artificial Intelligence*, p. 97.
14. Nilsson, *The Quest for Artificial Intelligence*, p. 413.
15. Mitchell, *Artificial Intelligence*, p. 103.
16. Nilsson, *The Quest for Artificial Intelligence*, p. 415; and Mitchell, *Artificial Intelligence*, pp. 133-134.
17. David Silver and Demis Hassabis, "AlphaGo Zero: Starting from Scratch," *DeepMind Blog,* 18 October 2017, available at https://deepmind.com/blog/article/alphago-zero-starting-scratch.
18. Michael Rutty, "Predictive Analytics vs. AI: Why the Difference Matters," *TechBeacon*, 10 February 2020.
19. The statistic of 200TB data collection first appeared in Bradley Wilson, et al., *Data_flood* (2014) as "every other day"; this number appeared once more as a daily collection intake more recently in Christian Heller, "The Navy Wants to Put its Head in the Cloud," *CIMSEC,* 21 January 2020. It is unclear whether this remains accurate, but the number provides a rough starting estimate.
20. Abeyon, "Military Sealift Command (MSC) Integration of Domain Knowledge and Machine Learning to Improve Reliability Maintenance," White Paper (2018), available at https://abeyon.com/wp-content/uploads/2018/04/Abeyon_WhitePaper_MSC.pdf.
21. *Ibid*.
22. *Ibid*., p. 2.
23. *Ibid*.
24. *Ibid*., p. 4.
25. David B. Larter, "The US military Ran the Largest Stress Test of its Sealift Fleet in Years. It's in Big Trouble," *DefenseNews*, 13 December 2019.
26. Kognitiv Spark, "Royal Canadian Navy to use Kognitive Spark's Software to Improve Vessel Repairs and Maintenance," Kognitiv Spark Blog, 26 March 2019, available at https://www.kognitivspark.com/blog/royal-canadian-navy-to-use-kognitiv-sparks-software-for-vessel-repairs-and-maintenance/.
27. "RCN to use Kognitiv Spark's Augmented Reality Software to Improve Vessel Repairs," *Canadian Defence Review*, 3 March 2019.
28. Janna Anderson and Lee Rainie, "Artificial Intelligence and the Future of Humans," Pew Research Center, 10 December 2018.
29. Mitchell, *Artificial Intelligence*, pp. 118-120.
30. Molly Kovite, "I, Black Box: Explainable Artificial Intelligence and the Limits of Human Deliberative Processes," *War on the Rocks*, 5 July 2019.
31. Paul Scharre and Michael Horowitz, *Artificial Intelligence: What Every Policymaker Needs to Know* (Washington: Center for a New American Security, June 2018), p. 15.

Megan Martins Da Ponte is a second year Master's (MSS) student at the Centre for Military, Security and Strategic Studies at the University of Calgary, and graduate fellow at the North American and Arctic Defence and Security Network (NAADSN).

Canada-US Defence Relations and the CSC: A Ship Too Far?

Dan Middlemiss and Denis Stairs

Credit: BAE Systems Maritime

*The forward and aft halves of HMS **Glasgow**, the first UK Type 26 frigate which forms the basis of the Canadian Surface Combatant, come together on 1 May 2021.*

The selection of Lockheed Martin Canada's (LMC) variant of the BAE Type 26 frigate as the winner in the lengthy competition governing the construction of the Canadian Surface Combatant (CSC) marked the culmination of a long process aimed at bringing the Royal Canadian Navy (RCN) into the forefront of cutting-edge naval technologies. Official statements have claimed that the CSC will be much more than a traditional warship. It has been described both as a 'digital ship' and as a 'node in a system of systems.' Its capabilities are expected to ensure that it will be a 'future-proofed' platform composed of systems that are software-enabled and readily upgradable to include the latest technologies as these are developed and become available.

This conception flows naturally enough from Canada's extensive experience of working with US naval forces (and frequently others, too) on an interoperable basis. But it goes beyond simple interoperability with key allies and coalition partners to include full 'integration' with Canada's chief naval ally, the United States. Hence, the CSC was also designed to incorporate the US-developed Cooperative Engagement Capability (CEC) with its elaborately integrated sensors, radar systems, data sharing and distribution equipment, and associated weapons systems.

Proceeding with the current CSC design, however, could pose unpalatable, albeit not yet clearly identified, problems for the leaders of either or both countries. The principal purpose of the discussion that follows is to draw attention to what some of these problems might look like. Space limitations have prevented us from offering as fully elaborated an account as we would like. Unavoidably, therefore, our treatment is incomplete and is not intended to provide a detailed review of the long history of Canada-US naval interoperability. We have been compelled instead to be very selective in choosing the issues we have addressed.[1]

It should be observed in any case that we are dealing with an uncertain and highly fluid set of circumstances.

It follows that many of our observations are unavoidably speculative. Ottawa, for example, has not yet approved a final ship design, and even the first of the ships to be launched may not be ready for operational service until well into the 2030s. Between now and then governments may change, priorities may be altered, and the geo-strategic environment may be transformed. The overall result could include fundamental changes in Canada's relations with its most important allies, the United States included.

The significance of this broad caveat is compounded by exogenous factors. The challenges posed on both sides of the border by the Covid-19 pandemic and the drain on public financial resources that has ensued are prominent among them.

With these caveats in mind, we begin with a brief summary of the current thinking behind the CSC (and CEC) proposals, along with the practical difficulties they could trigger. We will then consider some of the more general, and perhaps more obviously 'political,' manifestations of the problems at issue.

In the technical context, Canadian naval planners have for some time envisaged linking CEC equipment to the CSC's digital capabilities as a means of taking "interoperability to the next level," thereby "enabling systems integration both with other Canadian Armed Forces capabilities and our closest allies."[2] Their ambition reflects the American conception of the CEC as "a sensor network with integrated fire control capability that is intended to significantly improve battle force air and missile defence capabilities by combining data from multiple battle force search sensors on CEC-equipped units into a single, real-time, composite track picture."[3]

Even if they were to function as intended, the systems at issue could have a major impact on battlefield reaction times as well as on substantive rules of engagement (ROE). These in turn could have significant implications for the combatants, although they might vary with each of the naval forces involved. The procurement of the requisite technical gadgetry, moreover, could raise intricate issues related to 'burden-sharing,' American supply chain regulations, ballistic missile defence, and the like. While we do not have the space to treat such complicated technical matters in detail here, we will nonetheless return briefly to some of them below. In the meantime, we will consider some of the wide-ranging political issues that could also arise.

It may be useful to begin by reminding ourselves that the international distribution of power has profoundly changed, and is continuing to change, in the modern world. The relative capacities and degrees of influence at

Credit: LSIS Ryan Tascas, Royal Australian Navy

*The AN/USG-2 antenna used to transmit data as part of the Cooperative Engagement Capability can be seen in this 9 March 2021 photo of HMAS **Hobart**'s mast, taken during Exercise Tasman Shield 21 off Australia's east coast. The antennas are the two rectangular planar arrays in the centre (two more arrays face aft to ensure 360 degree coverage).*

the disposal of many countries have been altered as a result. Most notably, although by no means uniquely, the period of American dominance has been showing signs of decline, while the corresponding implications of the rise of China are everywhere becoming more evident. Not surprisingly, Americans are among those who are most worried by these developments, although some observers, even in the United States, think the case for this is overstated, and that the evolutionary process may take considerably longer than the pessimists expect. As opposed to those governed by more parochial preoccupations, the desire of 'establishment' Americans to restore and preserve their ability to influence the course of world affairs irrespective of the growing strengths of their rivals is a substantial driver of their position.[4]

The potential difficulty for Canada here is that it lacks the resources it would need in order to catch up with the force levels the Americans can mobilize. Even the two countries (Australia and Japan) that so far have decided to follow the American example are likely to discover that the security imperatives of their own areas will lead them in practice to focus most of their attention on fronts close to home. Their security aspirations could be constrained in response to other pressures as well.[5] In some situations Canada could have a little freedom of manoeuvre, but its capacity to contribute meaningfully to American-led undertakings might not be nearly sufficient to impress decision-makers in Washington. The marginal contributions of marginal players, after all, are commonly regarded by greater powers as no more than marginally (or, at best, symbolically) useful. They can sometimes help a little, but in themselves they almost never determine outcomes.

In these circumstances, American forces may see little advantage in 'integrating' Canadian naval operations too completely with their own, especially if such arrangements entailed the sharing of military technologies, intelligence information, digitally controlled weaponry, and the rest of the naval apparatus the United States envisages as central components of the very elaborately constructed CSCs the Canadian Navy has in mind. To the extent that the US Navy was willing in principle to operate in fully integrated style, it seems likely even then that it would be reluctant to share command functions and responsibilities with lesser players. The USN might be more inclined instead to see this as requiring 'too much give' for 'too little return.' It would almost certainly prefer to be in charge itself while leaving less militarily capable elements, Canadian ones included, to support American missions by doing no more than automatically following American orders. Certainly it would seem unlikely that following orders divined independently by Canadians is what the USN would find appealing.

Canadian and American purposes, in short, might not always mesh very well together in the changed international environment. The two countries have frequently been divided in the past, as over Cuba or the war in Vietnam, for example, or even over strategy in Korea. They have recently disagreed with the United States over policy on Iran, with Canada supporting the Europeans, and there seem to be major differences, on a variety of dimensions, over how best to respond to the challenges posed by China. This may turn out to be as true under the Joe Biden administration as it was under his diplomatically uncultivated predecessor, since the Americans are determined to keep Chinese ambitions firmly in check while Canada and other allies are more wedded to compromise polices reflected in postures of give-and-take. In these circumstances the United States would almost certainly want to act on its own rather than adapting to the inconvenient preferences of marginal players in pursuit of more modest objectives.

Differences of this sort, moreover, could easily arise much more frequently than the well-intentioned might expect, as the initiatives being conceived by the newly assembled White House even at this time of writing (early March 2021) might suggest. President Biden's refreshing support for multilateral institutionalism is certainly welcome, not least of all by Canadians strongly attached to multilateral approaches. But a close reading of the President's comments indicates that he expects his policies will actually have the effect of increasing American influence by drawing allies more fully under the American wing. This tendency may be perfectly understandable in the US context, but it may not seem to be entirely free of potentially irritating hazards when viewed from the allied vantage point.[6]

Canadian attitudes on international affairs more generally could also be a recurring source of policy disagreements between the two capitals. For a variety of reasons rooted in past practice and long experience, as well as in the modesty of the aspirations Canada can reasonably pursue with it limited capabilities, Canada is attracted to multilateral agencies as vehicles for diplomatic initiatives and to negotiation as the best approach in most cases for

Credit: Lockheed Martin

A screenshot taken from a promotional video for the Canadian Surface Combatant shows it sailing ahead of an American carrier strike group. The Cooperative Engagement Capability would allow raw radar data to be shared across all units equipped with CEC.

A graphic illustrating a 2016 test of Naval Integrated Fire Control - Counter Air (NIFC-CA), whereby an F-35B Joint Strike Fighter sent targeting data to a land-based SM-6 Standard Missile launcher to maximize the missile's range. CEC is an enabler of NIFC-CA

resolving or containing international differences. Washington, by contrast, is quicker to respond to conflicts by relying on the use of military instruments of persuasion. The United States usually has bigger fish to fry and feels it has wider interests to maintain, and it can pursue its objectives with massive resources at its disposal should it decide such deployments are warranted by the importance of the mission.[7]

The Canadian orientation has other origins, too, and not all of them would be universally regarded with favour. The most obvious of them, and in recent decades the most persistent of them, is a deeply rooted scepticism about the value of assigning significant financial resources to the military enterprise, whether at sea, in the air, or on the ground. Major conflicts sometimes generate a more positive response, but in the short term token responses are more common. Prolonged procurement delays, as in the case of the CSCs and in the lengthy stumbling over the replacement of fighter aircraft, have been the most frequent result.

The reluctance of the Canadian government to invest promptly and heavily in expensive new equipment is buttressed by the view that such expenditures would have no more than a modest impact on Canada's real military capabilities, while at the same time depriving the country of important assets that voters and politicians alike value more. Canadian economizing on military expenditures is not, of course, a welcome spectacle for American policy-makers to encounter any more than are similar displays by other allies. One of the common consequences has been a recurring American complaint to the effect that allies have not been willing to carry their full share of the defence burden. The greatly increased cost of the digitalized CSCs and their CEC equipment relative to that of earlier Canadian naval vessels will further aggravate this problem and add to the disappointment of naval officers who have been hoping to be supplied in the end with the best that money can buy. A certain irony thus lurks in the possibility that the enthusiastic support of Canadian naval planners for acquiring the most advanced gear that even the Americans can hope to contemplate will in the end prove so costly by Canadian standards that it forces them to lower their procurement aspirations. The effect could be to deprive them of precisely what they need to make their participation in US-led maritime operations acceptable south of the border. Seeking to earn diplomatic credit from a superpower that asks over and over again "What have you done for us lately?" becomes a perpetually futile endeavour.

There have been suggestions, nonetheless, that the CSC-CEC equipment combination, and especially the highly sophisticated and very expensive radar units it is intended to include, might make it possible for Canada to join with the Americans in fielding a ballistic missile defence (BMD) capability. But even if the United States were to favour this kind of cooperative initiative, it seems probable from past experience that Canadian defence decision-makers, along

Credit: Mass Communication Specialist 3rd Class Terence Deleon Guerrero

*The **Nimitz**-class aircraft carrier USS **Theodore Roosevelt** and amphibious assault ship USS **Makin Island** lead their escorts through the South China Sea on 9 April 2021.*

with most politicians and the public, would vigorously oppose Canada's participation on the ground that the missiles could have destabilizing effects.[8] Moreover, from a strictly naval standpoint, both Japan and the United States may have cause to question whether using scarce and expensive warships for continuous BMD picket duty is the most practical or cost-effective use of these assets.[9]

From the operational point of view, moreover, we have already indicated that some analysts are concerned that working too closely with the Americans in exploiting a thoroughly integrated CSC-CEC set of systems could greatly complicate the process of agreeing on the substance and enforcement of ROE. A key purpose of the CEC is to leverage the combined sensor capabilities of a battle fleet in order to improve the pace of decision-reaction responses. Having more time to react certainly makes eminent sense for a US naval battle group. Happily for the Americans, the realities of complex littoral operations, when combined with improved weapons systems such as hypersonic missiles, make reaction times nearly instantaneous using CEC capabilities.

For Ottawa, by contrast, the overriding issue is usually less about technical efficiencies of this sort and more about satisfying the pertinent politics. States like Canada handle the need for speed in operational settings by carefully formulating in advance of deployment the ROE that are to govern the actions of Canadian commanders in various circumstances. One obvious ROE example covers situations in which ship captains are granted permission to fire their weapons in self-defence if attacked by an adversary. But Department of National Defence (DND) Headquarters and politicians in Ottawa cannot foresee every situation that is likely to occur in the heat of a confrontation halfway around the world. Advance intelligence and related tactical information are thus crucial to the formulation of appropriate ROE.[10]

The history of US-led naval coalitions, however, has demonstrated that a Catch-22 principle is often at work. Coalition naval partners, Canada included, will not commit in advance to full-range ROE when US restrictions on the distribution of vital information and intelligence deny them access to the intent, and possibly the full scope, of an American-led mission. In return, the United States itself is likely to be reluctant to accept, trust and cooperate with maritime coalition partners that are not wholly committed to the enterprise it has in mind.

Put simply, the advanced capabilities of the CSC pose the question of whose 'net,' 'node' or other decision-making 'system' will be calling the shots under the integrated future envisaged for the CSC ships by Canadian planners. Such capabilities also raise the issue of whether the new CEC systems in practice would be too automated to permit timely overrides by Canadian commanders. As Paul Mitchell observed in 2003, "if the Canadian experience indicates that coalition network-centric operations are possible, it also indicates that the price of admission will remain very high. In a dynamic coalition environment, professional trust will be critical, and the height of the bar will be set by both technology and policy. Because of the crippling effect of slower networks or nonnetworked ships in such a setting, information releasability issues may be a stimulus to American unilateralism."[11]

In the case, moreover, of low-intensity 'gray zone' maritime operations, like those undertaken by Russia in Crimea

Credit: MCpl Manuela Berger, Formation Imaging Services Halifax

HMCS ***Toronto*** *(front) and vessels from other NATO partners sail in formation during Exercise Sea Breeze 19 in the Black Sea on 11 July 2019.*

and China in the South China Sea, we suspect that Ottawa will prefer its traditional recourse to non-military international and multilateral diplomacy to the more dynamic 'escalation dominance' and 'coercive gradualism' tactics currently advocated in US naval circles. The latest US strategic roadmap for tri-service maritime operations abroad features a much more confrontational approach to maintaining the rule of law at sea than we believe Ottawa would endorse.[12]

In all these cases, and in others certain to emerge, Canadians politicians are likely to face political conflicts that the Americans (absent Donald Trump) can more easily contain. The Liberal Party will have some reservations about a sophisticated CSC-CEC arrangement that would fully integrate Canadian and American operations. The New Democratic Party would hold similar views even more strongly, as would the Bloc Quebecois. The Conservatives are harder to predict. They might not object to the policy as a security-promoting arrangement or even as an American-dominated enterprise but they might strongly resist paying so hefty a bill as the one that would accrue to the 15-ship array of CEC-equipped CSCs upon which a fully integrated system would depend.[13]

Some observers might regard the foregoing discussion as overly negative, and it may be just that. But it is also possible that the concerns we have expressed are sufficiently worrying to warrant careful second thought by Canadian politicians and naval planners alike.

In effect, the ships and hardware Canada's planners currently want could turn out to be 'ships too far.'

Notes

1. For those seeking a useful overview of naval interoperability as informed by past practices, see Joel J. Sokolsky, "Sailing in Concert: The Politics and Strategy of Canada-US Naval Interoperability," *Choices*, Vol. 8, No. 2, Institute for Research on Public Policy, April 2002.
2. For an interesting overview of what the RCN is planning for the Canadian Surface Combatant (CSC), see, "Designing the Navy's Future Ships," featuring Rear-Admiral Casper Donovan, Director General Future Ship Capability, explaining the many ideas and factors currently shaping the design of the CSC. Canadian Global Affairs Institute, "Defence Deconstructed" series, podcast interview by Dave Perry with Rear-Admiral C.P. Donovan, 16 October 2020.
3. As defined by the US Department of Defense, the pertinent hardware includes "[a] Cooperative Engagement Processor, which collects and fuses radar data, and a Data Distribution System, which exchanges" this data. US Department of Defense, Director, Defense Operational Test and Evaluation, "Ship Self-Defense," Fiscal Year 2011 Annual Report, pp. 171-173.
4. For one of President Biden's many public disquisitions on this subject, see his White House Address, "America is Back," 4 February 2021.
5. See the revealing discussion of the Australian case in Marcus Hellyer, "Does the Royal Australian Navy need Tomahawk Missiles?" *The Strategist*, Australian Strategic Policy Institute, 16 February 2021.
6. See, David Carment and Dani Belo, "The Next Chapter in 'America First' Doctrine: The Joe Biden Era," Canadian Global Affairs Institute, March 2021; Lawrence L. Herman, "Government Procurement and Biden's Buy American Policies: A Way Forward," *Commentary*, Macdonald-Laurier Institute, February 2021; and Anthony Cordesman, "The Biden Transition and Reshaping U.S. Strategy: Replacing 'Burden Sharing' with Meaningful Force Planning," Center for Strategic and International Studies, 11 January 2021.
7. Such missions, needless to say, often fail, not least because policy-makers can so easily (and naively) fall into the trap of thinking that their targets will stand down in response not only to military assaults, but also to the weight of Western democratic ideals.
8. In this context, we do not consider the maritime warning mission of the North American Aerospace Defense Command (NORAD) to be politically problematic for either the Canadian or American governments. For a thorough overview of NORAD and its relatively new maritime warning mission, see Andrea Charron and Jim Fergusson, *NORAD: Beyond Modernization* (Winnipeg, Manitoba: Centre for Defence and Security Studies, University of Manitoba, 31 January 2019), especially "Chapter 6: Political Considerations," pp. 53-59. We note, however, that some of the issues involved more generally in the security field may prove to have different implications for policy-makers than they had in the days when the focus was on the defence of North America and when the deployed technologies were much simpler than the ones envisaged for the CSC/CEC era.
9. See, Loren Thompson, "Japan's Rethink of Aegis Ashore Could Tie Up Navy, Increase Costs and Cause Big Delays," *Forbes*, 11 August 2020; and David Larter, "The US Navy is Fed Up with Ballistic Missile Defense Patrols," defensenews.com, 16 June 2018.
10. While supporters of the CSC point to its proposed advanced communications and cyber warfare capabilities to increase decision-making time, it is prudent to note that such advanced systems would be subject to electronic jamming and sophisticated cyber attacks as well as possible disruption of vital satellite links during a serious maritime conflict. In short, the familiar fog of war may place greater reliance on pre-established Rules of Engagement.
11. See, Paul Mitchell, "Small Navies and Network-centric Warfare: Is There a Role?" *Naval War College Review*, Vol. 56, No. 2 (Spring 2003), p. 96.
12. See, US Secretary of the Navy, "Advantage at Sea: Prevailing with Integrated All-Domain Naval Power," December 2020. For an analysis which reinforces our view, see, Carment and Belo, "The Next Chapter in 'America First' Doctrine."
13. Canada, Parliamentary Budget Office, "The Cost of Canada's Surface Combatants: 2021 Update and Options Analysis," 24 February 2021. The PBO estimates the total cost of the CSC program at $77.3 billion or $5.15 billion per ship.

Dan Middlemiss and Denis Stairs are both retired professors of the Department of Political Science and former Directors of the Centre for Foreign Policy Studies at Dalhousie University.

Making Waves

Editor's Note: A small group of people read the Middlemiss-Stairs article before publication. We permitted two people to offer their comments in this issue. We hope there will be more comments in subsequent issues, or on Broadsides.

In Response to Middlemiss-Stairs Article

Hugh Segal

The design and systems scheduled for the new Royal Canadian Navy (RCN) surface combatants imply extensive interoperability with the US Navy. The excellent reflection on the viability (and desirability) of this approach by *CNR* Editorial Board colleagues Denis Stairs and Dan Middlemiss in this issue of *CNR* questions how advisable that may be in terms of both cost and effect. The underlying premise of their reflection is the different stance of the two states' foreign policies and therefore the naval rules of engagement they are likely to embrace now and in the future.

While this topic is indeed a valuable and important aspect of any naval procurement discussion, it strikes me that it is also important not to constrain our navy's tactical technical capacities going forward by undue anxieties around how foreign policy initiatives of allied countries may diverge in the future.

As we learned on the ground in Afghanistan, Canada's longest combat engagement ever, the transition from a stabilization role to an open combat mandate can and does happen. There were also aspects of this transition in Bosnia Herzegovina, when a United Nations (UN) stabilization mission became a robust NATO engagement aimed at repelling terrorist and related violent activity by Serbian and Croatian forces, regular and irregular.

Constructing our future army, navy, special forces or air force capacity based on our national preference for less violent, more Canadian-initiated combat sorties is like advocating that all cars in Canada only have summer tires because we prefer more temperate conditions. It is to carry self-reverential foreign and military policy instrument design to a whole new level of both arrogant and self-possessed complacency.

As a citizen, I want the women and men of Canada's navy to have all the war-fighting communication, Artificial Intelligence, firepower and real-time allied linkages necessary, and then some, to discharge whatever mission a particular context might require. The nature and rules of engagement for any mission will be decided by the government of the day. It would be a tragic constraint on that government's freedom to decide if the present government embraced design and equipment choices that diminish a realistic range of choice.

At a time when Russian aircraft and submarines, Chinese naval assets and cyber warfare capacities are being deployed in ever-more adventurous ways, and with aggressive intent, the men and women who navigate the world's oceans in RCN platforms above, on and under the seas need the full and best available weaponry,

Credit: Mass Communication Specialist 3rd Class Sierra D. Langdon

*HMCS **Calgary** sails alongside the aircraft carrier USS **John C. Stennis** during RIMPAC 2016 in the Pacific Ocean.*

communications and rules of engagement to discharge their mission alone or with allies.

It has often been said of present Russian and Chinese military doctrines that they are premised on having both the capacity to use force if necessary and, perhaps more importantly, the will to do so. It is in this latter area – the will to engage – that Western powers have sometimes been found wanting. This is a lack of will our authoritarian Chinese and Russian competitors may well seek to exploit.

From Crimea to the South China Sea, from the Straits of Taiwan to the Canadian Arctic, it has never been more important that our Chinese and Russian competitors, and their proxies worldwide, have no doubt about both NATO's capacity to engage and the will to do so when all else fails. That stance on the part of NATO was a seminal part of constraining the Soviets for decades after the Second World War.

In anti-submarine and allied patrol missions around the world, the RCN was an integral part of that successful NATO mandate. Our new Canadian Surface Combatants should have every technical and combat kit and state-of-the-art technological capacity to continue that global mission, especially with our democratic allies including, of course, our NORAD American partners.

Credit: Danish Defence Library

The steam-driven destroyer HMCS ***Nipigon*** *is seen here in Halifax Harbour in the mid-1980s.*

Comments on "A Ship too Far?"

Poseidon

Dan Middlemiss and Denis Stairs have written a very perceptive and thought-provoking article, published in this issue of *CNR*. In it they posit that the Type 26/Lockheed Martin variant of the Canadian Surface Combatant (CSC) is too expensive for this country, too complex for a medium maritime power like Canada, and that a Canadian task element composed of one or more CSCs might find itself hostage to American aims and objectives if it were part of an American task force.

They imply that a capability to network with American units in order to engage attacking ballistic or cruise missiles – referred to as Cooperative Engagement Capability (CEC) – may be destabilizing and therefore something that Canadians shouldn't be involved in. This debate has occurred before, especially in the 2005/2006 period. I don't think that should be a valid concern in a tactical situation, i.e., an attack against an allied task force on the high seas.

The article also implies that the Americans might see the incorporation of a less-capable Canadian element in a task group as undesirable and difficult due to adherence to different rules of engagement. Navies from countries such as Australia, Canada, France, Germany, Italy, Japan, the Netherlands, Spain and the UK have provided high-readiness ships and well-trained crews to operate with American task forces for years. They are at least as effective as most US naval vessels, except for nuclear-powered aircraft carriers, of course. They all practice and refine NATO tactics and procedures so that they can operate effectively together. Canada has been doing this for a long time, and when it provides a ship to deploy with the Americans, they consider it a full replacement for their USN equivalent.

The only real issue is the quality of the ship and its ability to do the job. During the Cold War, those of us who went to sea in steam destroyers knew that if the 'balloon went up' we were going to have a hard time of it against the opposition in the North Atlantic. We had excellent sailors and seaworthy ships, but we lagged behind the threat posed by the Soviet Navy. If Canada is going to be an effective partner on the world stage, it must spend what is necessary to provide adequate tools and training so that Canadian sailors can do the job expected of them and have a good chance of coming home safely afterwards.

Long-term Operations and Sustainment Costs for the CSC

Mikaël Perron

It has been estimated by some sources that the long-term Operations and Sustainment (O&S) cost of the Canadian Surface Combatant (CSC) might be in the waters of $143 billion on top of a $60 billion procurement cost. It was estimated based on historical data that shows an average O&S cost of 2.7 times the acquisition cost for an estimated service life of 30 years. This makes perfect sense in most cases and especially with complicated and cutting-edge weapon systems such as the F-35 with a flying cost of $40,000 US per flying hour so far. A deeper look into the design features of the CSC available within the public domain, however, leads me to predict an O&S cost not much higher than the *Halifax*-class frigates. While the software upkeep costs of the new technology of the ships are hard to predict, they will probably be very high. But the open architecture of the different management system within the ship will make easy different upgrades and modifications through time.

The first point of cost control is the crew size which is a significant overall part of the budget of the Canadian Armed Forces (CAF). According to released information about the CSC, the full complement of the ship is said to be around 204 although it is not mentioned if this includes flag staff or air detachment crew. The UK version is said to have a complement of 157 with accommodation space for 208 persons. If we compare the CSC with the ships being replaced, we had an official crew of 285 persons on an *Iroquois*-class destroyer and 225 on a *Halifax*-class frigate. I can remember that most of the time when we left for a NATO deployment on a frigate we had about 235 crew onboard. The CSCs, therefore, will have fewer personnel and thus this will not represent an increased cost to O&S. As well, because there will be fewer classes of ships with only one version of the CSC being built, there will be less training requirements for crew transferring from one class of ship to another one.

The CSCs will provide benefits for maintenance too. The usage of an integrated mast with solid state radars means for easier and safer maintenance of the different radars. In

*Credit: Capt Jenn Jackson, HMCS **Ottawa** PAO*

*Commodore Angus Topshee, Commander Canadian Fleet Pacific, addresses the crew of HMCS **Ottawa** while alongside Yokosuka, Japan, on 15 October 2019. The crew size of the Canadian Surface Combatant is expected to be smaller than that of the **Halifax**-class, reducing its impact on operating costs for the new ships.*

Credit: Sailor First Class Bryan Underwood, Canadian Armed Forces

*A sailor on HMCS **Halifax** inspects one of the ship's MWM602 diesel engines that help provide power to the ship. The engines are being replaced as part of the **Halifax**-class midlife refit, and HMCS **Halifax** will receive its new C32 ACERT Caterpillar diesels after coming out of its 2023 docking work period.*

the past, sailors went up the mast for maintenance. This will not likely happen with the CSC design since they will go up inside the mast safely sheltered from the outside elements. As well, the fact that the ship will be fitted with solid state radars means all the moving parts from legacy radars (motors, bearings, gear train) will be absent from the ship, thus reducing the maintenance requirements.

To me, as an ex-Marine Engineer Technician, the biggest improvement of the CSC lies in the efficiency of the power plant design. It will lack the power-to-weight ratio of the Canadian Patrol Frigates (CPF) (the *Halifax*-class) that allows them to go from 0 to 30kts in a minute and to get from full speed ahead to a dead stop in about a length of the ship, but it will offer much more efficiency.

To compare them we need to go a bit technical, although I will save you most of the number crunching. A CPF is propelled through the water via three standard propulsion modes. It uses a cross-connect gearbox that allows for a 6.6 MW V20 Pielstick propulsion diesel engine (PDE) to drive the ship up to 18kts through two controllable reversible pitch propellers (CRPP) consuming about 1,700 litres of fuel an hour at full speed. You can use either one of two 17.6 MW LM2500 gas turbines to drive the ship up to 26kts using 5,500 litres of fuel an hour at full speed or both gas turbines simultaneously to achieve a speed of 30+kts now using 11,000 litres of fuel an hour. On either drive mode, you are usually using two out of four V16 850 KW diesel generators to supply around 1 MW of electrical power for hotel load (electrical power used to power everything on the ship except the propulsion itself). Any one of the diesel generators consume about 240 litres of fuel an hour at 100% load. This gives the commanders a lot of redundancy and flexibility, but the engines are often not used in their most efficient power range. While quite efficient in the speed around 12-15kts, the PDE is often used on transit and low intensity operations, it is never used close to shore or near other vessels or for heavy manoeuvres.

The CPFs always operate on both gas turbines when near the shore or other ships, and gas turbines are not efficient

at all below 35-40% of power output. (We will not mention the *Iroquois*-class destroyers here because they were way less efficient, especially on their previous generation design FT4 main gas turbine.) The CPF's diesel generators were a major cost driver for the RCN. They were operating between 50-60% load most of the time (the usual hotel load is too high for single diesel operation but a bit low for twin diesel operation) and had a major tendency to develop carbon deposits that often led to engine failure. (A crust of carbon would accumulate on the engine piston and fuel injector, and pieces of the crust could detach and cause engine failures.) A lot of effort was deployed to address the issue but no 100% solution was developed. The RCN went through a lot of engine blocks and the procedure to replace these engines involves removing parts of the ship decking to hoist up the engines. That is very time- and money-consuming. Happily, the latest updates to the CPFs involve the replacement of those engines with a new model.

If we turn our attention to the CSC, it will use four Roll-Royce diesel generators of 3 MW output each to supply electric power to both fixed pitch propellers and hotel load simultaneously. This allows the commander to modulate the number of operating engines so they operate most of the time at their peak efficiency which is about 75% load for a diesel engine. Each engine uses about 583 litres of fuel an hour at 75% load and about 741 litres of fuel at 100% load. The same engine type is already in use in a similar configuration on the German F125 frigates. These engines are upper tier category and are meant to operate for over 24,000 hours before any major overhaul. The generators supply enough power together to propel the ship up to 20kts on electric motors. The main transmission will not be used on electrical propulsion mode, saving even more wear and tear on the drive train.

In addition to greater energy efficiency, thanks to the torque and responsiveness of the electric motors, the CSC will probably be more manoeuvrable than the CPF at speeds below 20kts and will presumably operate on only two diesel generators at speed of 15kts and below. The RCN will probably have already developed standard operating procedures from operating the similar diesel-electric power plant of the Arctic and Offshore Patrol Vessels (AOPV). This means that the powerful single 36 MW MT30 gas turbine installed on the CSC will almost exclusively be used for speeds above 20kts which count for a very small percentage of sailing time. That engine is about 8% more efficient than the LM2500 on paper meaning that a CSC sailing at about 28kts would use just a bit more fuel than a CPF sailing at 30.8kts. Of course, to get to 30kts the CSC would require something like 45 MW and probably about 50 MW to reach 30.8kts, according to the rule of thumb when we compare the displacement of each ship.[1]

The CSC probably possesses a better hydrodynamic form judging by the hull profile of different models displayed, and fixed pitch propellers are usually slightly more efficient than CRPP propellers due to their smaller hub free of the moving piston in the centre. The absence of a CRPP system also removes a complex and expensive system to maintain and repair. The CPFs are more economical when operating on a single gas turbine between 20 and 26kts but they revert to two gas turbines when operating near other ships. In any case, the CSC propulsion plant is to be made of top-quality prime movers and is designed so that the ships will almost always be operating at their peak efficiency.

The CSC may lack in speed somewhat compared to the CPFs, but I would rather lose 2-3kts top speed and possess the sensors to react to incoming supersonic missiles or torpedoes incoming at 60kts. As well because all missiles in the CSC will be in vertical silos this means a lot less maintenance. The effectiveness will also be enhanced, especially when you consider the Sea Ceptor's close-in defence missiles to be used on the CSC vs the maintenance-heavy Phalanx close-in weapon system of the CPFs that cannot properly stop a supersonic incoming missile due to the low kinetic energy of its 20mm bullets. While the shooting of missiles will be more expensive on the CSC, I would not see them firing many more missiles than the CPFs do now once the systems are proven.

So, when the cost of the crew, fuel and maintenance is considered, there is hope that Canada might end up with a decent O&S cost. Of course there are some worries. While the official data give a displacement of 7,800 tonnes, the outgoing CEO of Irving Shipyard (ISI) mentioned a full displacement of 9,400 tonnes in his latest interview. That would be a totally different game. That is about the same displacement as a Flight IIA *Arleigh Burke*-class destroyer! I wonder if the gas turbine would be able to maintain the specified speed of 27kts or the diesel-electric mode would be able to reach 20kts in these conditions. *Arleigh Burke*-class destroyers cruise on two 19.5 MW gas turbines but add another two to reach speeds above 30kts. They do not possess the range of a CSC or CPF but the US Navy possesses a large fleet of supply ships, while the official intent of the Canadian government is to rely only on two Joint Support Ships (JSS). There is the hope that MV *Asterix* will be purchased to provide additional support to the fleet considering the addition of the six *Harry DeWolf*-class ships and the ever-growing need for disaster relief operations around the world.

The CSCs have the potential to make a great contribution to our security and also on the world stage. The CSC project must be brought to full completion but with complete and efficient oversight and transparent and regular progress reports to the government and Canadian citizens.

Notes

1. To explain a bit more, a CSC at full power going between 27-28kts will probably use about the same amount of fuel as a CPF also at full power but going at 30.8kts. Both CPF engines produced 35.4 MW together vs 36 MW for the CSC single main engine. Thus, if you would want the CSC to go as fast as the CPF, you would probably need at least 50 MW of propulsion power. That would require a lot more fuel and a lot of modifications.

The LSI(A): An Arctic Sovereignty Protection Option?

Major (Ret'd) Les Mader[1]

Writing before the COVID-19 pandemic started, Colonel (Ret'd) Brian Wentzell and I each made suggestions for providing Canada with a sea-based capability for protecting its Arctic sovereignty. In an initial article, Colonel Wentzell argued persuasively for the benefits to Canada of being able to respond to Arctic crises using a ship-borne force.[2] He proposed the use of existing – or being-procured – Royal Canadian Navy (RCN) ships (Arctic and Offshore Patrol Ships (AOPS) and Joint Support Ships (JSS)) to deploy and support a half-battalion of soldiers during a crisis. Building on this (basic) capability, I suggested in a subsequent article a more elaborate option that was designed around a notional 16,000-20,000 ton Landing Platform Arctic (LPA), which would be a Landing Platform Dock that was designed for polar operations.[3]

The massive deficits that the Canadian government has incurred due to COVID-19 make the LPA concept seem unaffordable. Colonel Wentzell's basic capability remains, however, fully achievable but constrained by the performance limitations of the AOPS and JSS. This situation raises the question of whether a ship option exists that is more Arctic- and amphibious-capable than the AOPS and JSS, while being much cheaper than the LPA. I believe that such a ship could be produced. This article will describe the envisioned vessel, which I have called a Landing Ship Infantry (Arctic) (LSI(A)), as no nomenclature currently in use really fits what is suggested.

An LSI(A) with the following operational characteristics (quantified, where possible, in Table 1) would provide Canada with a very worthwhile capability:

- It must be very seaworthy in order to help keep its embarked marine infantry as fresh as possible, even when sailing in the Bering Sea and the North Atlantic, possibly in winter;
- Its speed, endurance, range and sea ice capability must be at least as good as those of the AOPS, with which it may operate;
- Given the operational concept that, in the Arctic, small numbers of well-trained, properly-supported soldiers can have an impact out of all proportion to their numbers, a company of marine infantry would be an operationally valuable number of troops for the LSI(A) to be able to carry, deploy, support and recover;
- It must provide its embarked marine infantry with the facilities needed to maintain their physical strength, endurance and skills while at sea for weeks. As a minimum, facilities are required for marching, strength training, stamina and weapons handling;
- Its smaller size will probably exclude the provision of a well-deck to carry, launch and recover landing craft. This exclusion will make helicopters its principal means to transport marine infantry to/from shore. On the basis of helicopters having a 75% operational availability, at least three transport-configured Cyclone helicopters will need to be carried to be able to move a marine infantry platoon in one lift.[4] Four Cyclones would provide a much higher level of capability and redundancy;
- While helicopters will be its primary troop delivery means, a number of landing craft in davits (Landing Craft, Vehicle, Personnel (LCVP) and light hovercraft (LCAC(L)) (if deployable by such means) would greatly increase operational flexibility and capability. These landing craft will be essential for landing and recovering any embarked Bv-206-like all-terrain vehicles that are carried in order to enhance the marine infantry's logistics support and ability to deploy heavier weapons and equipment; and
- The LSI(A) must be able to defend itself against air, surface and missile attacks.

While seemingly quite a demanding list, the Danish Navy's *Absalon*-class multi-role support ships provide a real-world confirmation of what can be accommodated within a destroyer-like volume and displacement. Armed with frigate-level firepower, but built around a 915 metre[2] flex Roll On/Roll Off (Ro-Ro) deck, the *Absalons* can fulfil a multitude of different functions, depending on how the flex deck is configured: troop transport (using temporary

sea container-based accommodation); vehicle transport; hospital; mine layer; or command ship. Their major characteristics are described in Table 1.

While the *Absalons* are not ice-capable, I believe that they provide a valuable point of departure to discuss the feasibility of a Canadian LSI(A). Designing an ice-capable LSI(A) hull form that has the length of the *Absalons* as its starting point will result in a greater beam than theirs, with the resultant increase in both internal volume and displacement.

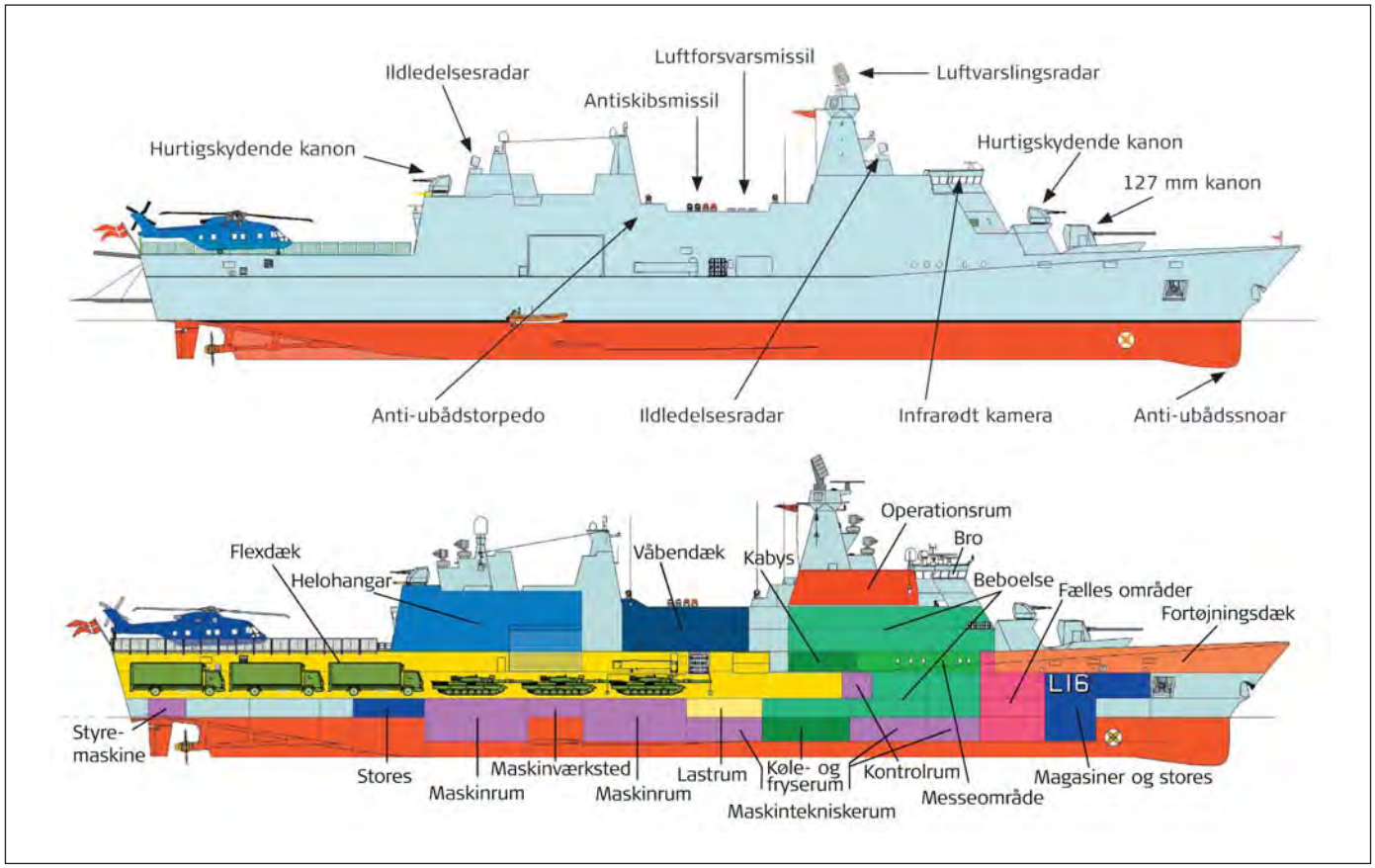
As Table 1 clearly shows, a very capable LSI(A), which has the key capabilities of the *Absalons*, can be built inside such a hull. It would be able to carry, deploy, support and recover a marine infantry company using helicopters, and landing craft where sea ice conditions permit. This level of amphibious performance would not be obtained by sacrificing a robust self-defence capability. The LSI(A)s would carry a broad range of anti-ship, anti-air and anti-missile weapons. Thus, these ships would be a very valuable asset for the Canadian government, both for demonstrating Arctic sovereignty and responding to a polar crisis.

Careful engineering would be required to ensure that the LSI(A)s meet the following three key operational characteristics that the *Absalons* currently cannot meet:

- Embarking four Cyclones;
- Providing the marine infantry with adequate training and fitness facilities; and
- The amphibious landing and recovery of Bv-206-like vehicles.

The needed volume for these characteristics can be found by careful design and due to the fact that the LSI(A) is focused on one task rather than trying to accomplish many very different roles. Some ways that the necessary internal volume can be found in order to incorporate these requirements are:

- The greater relative beam of the LSI(A)'s ice-capable hull form;
- Reducing the weapons carried either in terms of the number of weapon systems or their ammunition loads;
- The economies achievable through the construction of purpose-built marine infantry accommodation compared to the inefficiency of the containerized temporary quarters of the *Absalons*; and
- The fact that the lower speed requirement may



Credit: Forsvarsgalleriet (Danish Defence gallery)

*The Danish **Absalon**-class support ships (now re-rated as anti-submarine frigates and slated to receive variable-depth sonars) are notable for their inclusion of a flex deck highlighted here in yellow which has significant carrying capacity for vehicles. These can be offloaded in prepared ports via a stern ramp.*

Table 1: Key Characteristics HDMS** Absalon **and Representative LSI(A)

Criteria	Key Operational Characteristics L16 HDMS *Absalon*	Suggested Key Operational Characteristics LSI(A)
Displacement (Full Load) (tons)	6,300	>6,300. Will grow when provided with an ice-capable hull
Length (metres)	137	137
Beam (metres)	19.5	25.27 (from AOPS 103/19 length/beam ratio, which is linked to its ice-capable hull form)
Speed (knots) (kts)	23	At least 17 (from AOPS)
Endurance (days)	28	About 120 (from AOPS)
Range (nautical miles)	9,000	At least 6,800 at 14 kts (from AOPS)
Crew	100	About 100
Passengers	200. 70 in accommodation; 130 in containers on flex Ro-Ro deck	200. Including landing force command, marine infantry company, aviation flight, landing craft crews, and additional support personnel (cooks, medical, etc.)
Marine Infantry Training Area	Not mentioned	Required
Helicopters	2 x EH101. Elevator between the flight deck and the flex deck	3-4 x Cyclones
Landing Craft	2 x fast personnel craft	2 x LCVPs in davits 2 x LCAC(L) in davits (if possible)
Sea Ice Performance	None	At least Polar Class 5 (from AOPS)
Cargo	915 metre^2 flex Ro-Ro deck	Carry Bv-206-like vehicles
Weapons	16 x Harpoon AShipM 36 x Sea Sparrow SAM 1 x 127mm cannon 2 x 35mm CIWS Torpedoes	Similar. Perhaps somewhat reduced

Information compiled from: Naval Technology, "Harry DeWolf-Class Arctic/Offshore Patrol Ships (AOPS)," https://www.naval-technology.com/projects/harry-dewolf-class-arcticoffshore-patrol-ships-aops/; Naval Technology, "Absalon-Class Combat/Flexible Support Ship," https://www.naval-technology.com/projects/absalon/; RCN, "Arctic and Offshore Patrol Ship Project," http://www.navy-marine.forces.gc.ca/en/fleet-units/aops-home.page; and Jeff G. Gilmour, "Arctic Icebreaking Operations and the NSS," Canadian Naval Review, Vol. 16, No. 1 (2020), p. 22.

allow for less volume to be allotted to the engine room and its ancillary spaces.

Canada's Arctic sovereignty will be challenged sooner or later. A ship-based response capability, such as Colonel Wentzell has proposed, will thus be essential. Given the limitations of the AOPS and JSS as Arctic amphibious ships, the basic capability that he has suggested should be augmented to provide the Canadian government with greater operational flexibility and capacity. The LPA option proposed earlier does not seem to be affordable as the chosen enhancement. However, this article has shown that the LSI(A) can be achieved and offers a valuable and significant increase in response capability. The RCN should carry out an initial feasibility study to determine the higher level technical specifications for an LSI(A) that can be built in Canada and the macro-level cost of such a vessel.

Notes

1. The author wishes to thank Guy Lavoie and Diane Mader for their editorial input.
2. Colonel (Ret'd) Brian K. Wentzell, "Arctic Amphibious Capabilities for Canada?" *Canadian Naval Review*, Vol. 15, No. 2 (2019).
3. Major (Ret'd) Les Mader, "A Suggestion for an Intermediate Level of Arctic Amphibious Capability," *Canadian Naval Review*, Vol. 16, No. 1 (2020).
4. This quantity is an estimate. It is based on a Cyclone being able to carry up to 22 passengers depending on their equipment, weather, and the need for survival suits. See Lockheed Martin, "CH-148 Cyclone Canada's Maritime Helicopter," available at www.lockheedmartin.com/en-us/products/sikorsky-ch148-cyclone-helicopter.html.

A View from the West:

The Quad 2.0 and Maritime Cooperation in the Indo-Pacific Region

Jocelyn Sandhu

The 'Quad,' a group of four democratic countries – Australia, India, Japan and the United States – with shared concerns and strategic interests in the Indo-Pacific region, first appeared on the periphery of the 2007 ASEAN Regional Forum meeting. For years it remained low key, but 14 years after its formation, it has returned to the international stage, driven primarily by an increasingly aggressive China. Its initial revival in 2017 – a comeback which earned it the name 'Quad 2.0' – has been amplified this past year by high-profile meetings, joint military exercises and statements outlining each country's goals and visions for the grouping. On 12 March 2021, another milestone was reached when the Quad heads of state met virtually for the first time under the forum's banner, and together penned an article published in *The Washington Post* stating that the group was determined to ensure that the Indo-Pacific region be a region "free from coercion" and governed by international law, a not-so-subtle rebuke to China.[1] This first summit of the Quad signaled that the group intends to stick around, and also revealed what can be expected from it in the future. The Quad seems to have changed from an ambiguous security dialogue with an unclear trajectory to a grouping whose similar challenges have necessitated a closer and more coordinated approach to their engagement in the region.

Far from an 'Asian NATO,' as some of its critics – China included – have suggested, Quad members have emphasized the group's ability to foster regional cooperation. Although it has been accused of seeking to encircle China, it is more accurate to suggest that it is seeking – although not explicitly – to influence China's behaviour and policies. Unlike a formal alliance, the Quad is a group based on flexibility, allowing members to determine the level and nature of their participation in joint initiatives, and providing the option for any 'plus' partners to engage with the grouping on their own terms.

*Credit: Corporal Lynette Ai Dan, HMCS **Calgary**, Imagery Technician*

*From front: Her Majesty's Australian Ship (HMAS) **Sirius**, HMAS **Anzac**, HMCS **Calgary** and Japanese Ship **Akebono** sail in a line during **Operation Projection** in the Indian Ocean, 8 April 2021.*

The Quad's COVID-19 vaccine distribution initiative announced in March 2021, for instance, will use funding from Japan and the United States to expand vaccine production in India, which will then be distributed by Australia across Southeast Asia. An initiative like this will allow the group to demonstrate that it is capable of using individual state resources, partnerships and capabilities to provide concrete solutions to pressing issues in the Indo-Pacific region. This type of arrangement will also create a model for the group to pursue further collaborative projects on other non-traditional security issues, such as climate change, cyber security and the use of space, with other regional stakeholders. However, an emphasis on non-traditional security issues is a relatively new development for the group, the foundation of which is rooted in shared concerns over the state of security in the Indo-Pacific region, more specifically, the state of maritime security.

Maritime security is an issue that affects the entirety of the Indo-Pacific region, and is an intrinsic part of the Quad's shared concept of a free and open region. Quad members have emphasized maritime cooperation since their first meetings, and in 2007 the first quadrilateral engagement was a maritime one, when all four members participated in the Malabar naval exercise. Although fear of damaging its relations with China caused India to exclude Australia from participating in Malabar in the years following the 2007 exercise, India shed this hesitance and invited Australia back in 2020. This signaled that even India, the most hesitant Quad power, saw maritime cooperation within the framework of the Quad as a strategic necessity in the face of a more assertive China at sea. The participation in the 2020 Malabar exercise of all four members led officials in China to shift their tone on the Quad to a more alarmist one, indicating that the group's maritime cooperation has been perceived by Beijing as a threat to its interests in the region.[2]

All four Quad countries have been confronted with a shared challenge: a rising regional power that selectively respects international laws and norms, and allows Chinese interests to reign over principles such as freedom of

Credit: Petty Officer 3rd Class Arthur Rosen

*USN Commanders Robert J. Briggs and Richard D. Slye monitor the Chinese aircraft carrier **Liaoning** from USS **Mustin** while in the Philippine Sea.*

navigation, territorial claims and commitment to peaceful resolution of conflict. Provocative actions at sea by China – such as island building, the build-up of its massive fishing fleet, and employment of its maritime militia to harass vessels from elsewhere in the South China Sea (SCS) – have pushed naval cooperation to the forefront of the Quad's agenda. From repeated incursions into Japanese territorial waters around the disputed Senkaku Islands, to the pursuance of logistical facilities in the Indian Ocean, to the condemnation of US Navy transits through the SCS, and overtures to Pacific Island states, China has made a point of infringing on the strategic maritime interests of each of the Quad's member states. Its actions have destabilized and undermined international law in a region deemed strategically critical to all four countries, and as a result has brought them into closer cooperation with one another. Shared challenges extend beyond China, however, as rogue actors like North Korea have also challenged maritime stability. Additionally, disputes over maritime delineations and offshore resources, as well as piracy and illegal, unreported and unregulated fishing are prevalent problems in the region. As such, it is crucial that addressing maritime security issues remains central to the Quad's engagement in the Indo-Pacific region.

Exercises to improve interoperability, capacity building and maritime domain awareness are all activities in which Quad members have been engaged for decades. However, the framework of the Quad means its members can pool their resources, partnerships and capabilities to foster more effective and broader cooperation in the region, and provide Indo-Pacific stakeholders with flexible opportunities to engage with a group of highly capable maritime countries united by common goals. The Royal Canadian Navy (RCN), for example, consistently deploys to the region, and has engaged with Quad member states at sea bilaterally and trilaterally. The closer maritime integration of Quad members will provide Canada with more opportunities to engage with a group of countries dedicated to the same principles it is seeking to uphold. In January, the Royal Canadian Air Force participated in this year's Sea Dragon exercise with all four Quad members, and opportunities for the RCN are sure to follow.

Quad members' individual engagements with other states will remain important as the enhancement of these partnerships widens the resources of the entire Quad. For Southeast Asian states, for which the SCS remains a potential flashpoint for conflict, the Quad provides an additional avenue through which they can engage with like-minded maritime partners. Such engagement does not demand that these states choose collaboration with the grouping over engagement with China, which remains an important economic partner for many of them.


Credit: PO Dave Jenkins, Royal Navy

*HMS **Queen Elizabeth** departs Portsmouth for Exercise Strike Warrior on 1 May 2021, after which it and the rest of its strike group will continue on to the carrier's maiden operational deployment to East Asia.*

The Quad has been revived at a time when maritime powers that have long been absent from the Indo-Pacific region, such as the UK and Germany, have signaled that enhancing their naval presence there will be a crucial component of their future engagement. Fostering maritime cooperation and capacity building in the region will be a critical part of solidifying the grouping as a staple of the security architecture, and will contribute to the creation of more stable conditions at sea. The maritime realm is one in which China continues to test the resolve of regional and extra-regional states. It is likely that only concrete challenges to China's advances, such as a Quad committed to maritime cooperation, will lead to behavioural change at sea.

Notes

1. "Our Four Nations are Committed to a Free, Open, Secure and Prosperous Indo-Pacific Region," *The Washington Post*, 13 March 2021.
2. Joel Wuthnow, "China's Shifting Attitude on the Indo-Pacific Quad," *War on the Rocks*, 7 April 2021.

Jocelyn Sandhu is an Analyst in the International Engagement section at Maritime Forces Pacific in British Columbia. The views and opinions expressed in this article are the author's own.

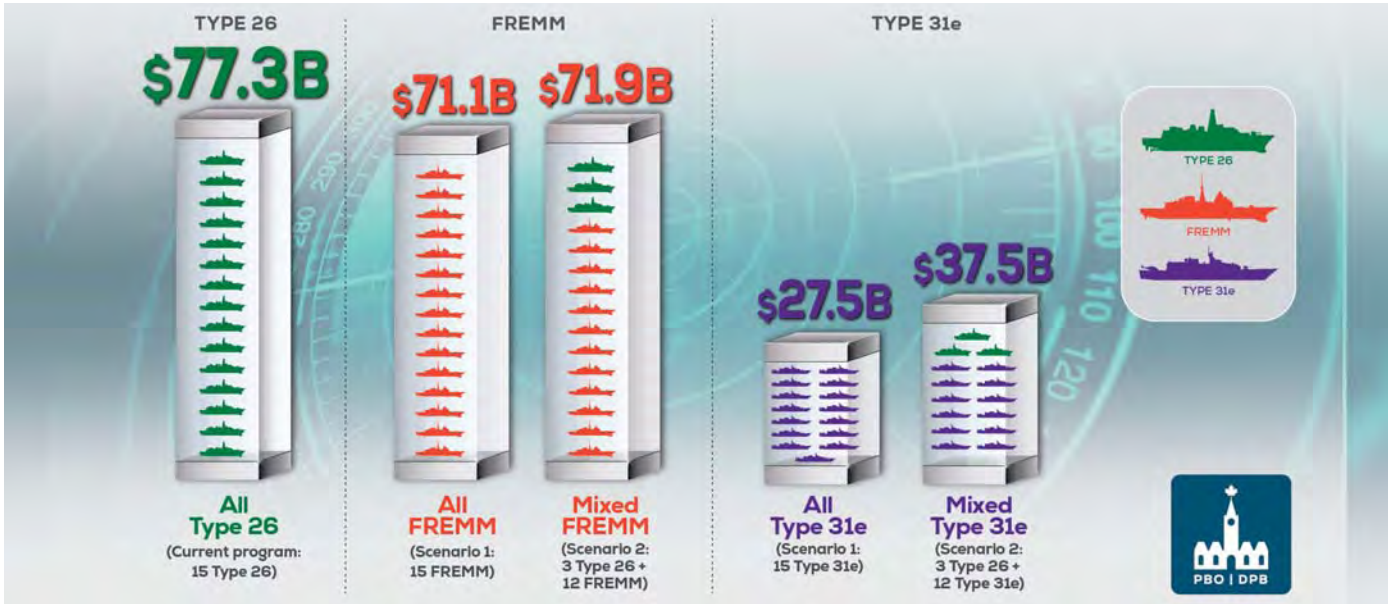
Dollars and Sense: Shipbuilding, Moving Forward

Dave Perry

Canada's shipbuilding projects cleared an important hurdle this winter with the release of both an Auditor General (AG) report on the National Shipbuilding Strategy (NSS) and the Parliamentary Budget Officer's (PBO) revised estimate of the cost of the Canadian Surface Combatant (CSC). The essence of the AG's report was that all of Canada's shipbuilding projects are behind schedule, but shipbuilding is difficult. More than one former Canadian procurement executive likely read that report envious of such an empathetic audit, and the fact that the Ontario edition of *The Globe and Mail* the following day did not even mention the study! The PBO report showed billions of dollars would be needed to build CSC, but also that switching tracks to a different, relatively comparable, ship design, something often touted as a cheaper way to proceed, would provide miniscule savings. One way to interpret the findings of both officers of Parliament, which presented nuanced reports, is that collectively the government of Canada's understanding of shipbuilding is maturing.

As I have noted in previous columns, there was reason to think that, given the past problems the Royal Canadian Air Force experienced with its fighter projects in the wake of AG and PBO studies a decade ago, the CSC project might be in for a rough ride. But the two reports already seem to be out of the way. The Department of National Defence (DND) welcomed the AG's recommendations, and essentially said, 'thank you, but we are confident in our own numbers,' to the PBO. With that, the projects are moving ahead, albeit perhaps not at full steam. With those reports now in the rearview mirror, the path forward on the large projects, CSC in particular, seems to be relatively clear.

The PBO's report had mixed messages about the costliest project in the NSS large ship portfolio. The report pegged the cost of 15 CSCs at $77 billion, an increase of 11% from its last estimate in 2019, and well higher than the $60 billion upper end of DND's estimated cost range for the vessels. Curiously, the gap between the PBO and DND numbers would close significantly, by about $6 billion, if DND included the same applicable taxes as the PBO. Irrespective of whether the PBO is correct to include the taxes, or DND to exclude them, it is frustrating that such a simple, yet consequential discrepancy between the costing approach of the PBO and DND still exists more than a decade after the PBO started costing defence projects. In comparison to a taxes-in DND budget estimate of $66 billion, the PBO's estimate is roughly $11 billion higher. In dollars, the variance between the cost estimates is substantial, larger than almost all other DND capital projects and the budgets of most other federal departments. As a percentage variance, the PBO's estimate is 17% higher than the upper end of the DND project budget range, a range that is less stark than the absolute dollar variance, given the significant differences in the approaches employed. While the PBO uses a parametric approach using the PRICE TruePlanning software and key ship characteristics such as weight, DND is engaged in a ground up costing using equipment and systems cost information provide by vendors, labour estimates and wage rates, which makes the variance less surprising.[1]



Credit: Parliamentary Budget Officer

A graphic in the February 2021 PBO report illustrates the relative costs of alternative CSC design options that the PBO was asked to examine by a parliamentary committee. The report acknowledged that while the FREMM is comparable to the Type 26 CSC, the Type 31 is a much different and less capable vessel.

The Norwegian-produced composite mast for the first UK Type 26 arrives at the BAE System shipyard in Scotland. In the background is the ship's bow. The Canadian version will have a different mast.

Perhaps the most unique, and valuable part of the report, was the PBO's cost comparison of the CSC with two other ships, the Royal Navy's Type 31 frigate and the version of the French/Italian FREMM the US Navy plans to build under its *Constellation*-class frigate project. The choice of those two ships for comparison was questioned by some analysts, but as Parliamentary Budget Officer Claude Giroux explained, the parliamentarians who request the study get to decide the research questions.[2] Within the constraints of the report's assumptions (which included assuming the same industrial strategies would be used, and did not factor in the full costs of adapting the ships to meet Canada's specific requirements), buying the FREMM would cost between $71-$72 billion, and the Type 31 $27.5 and $37.5 billion.

The FREMM was one of the ship designs that had prequalified during the CSC Request for Proposal (RFP) process, and the specific version examined is being built by the USN, making it a sound ship to use as a point of comparison. The PBO estimated that purchasing either 15 FREMMS, or building 12 after building three CSCs (again, without modifying it to meet Canadian requirements) would only save Canada $5 or 6 billion, respectively. As outlined, under the same two scenarios, building a fleet of the Type 31 frigates could cost between $50 and $40 billion less than proceeding with CSC as intended. Importantly, the Type 31 was designed as a less capable vessel to complement the Royal Navy's fleet which includes the Type 26 design that Canada has enhanced into the CSC envisaged today. One way to interpret these cost comparisons is that they show building something reasonably analogous to (but not the same as) Canada's CSC would cost roughly the same amount of money, if built in the same manner and using a consistent budgeting approach. Only by opting to purchase a significantly less capable ship could Canada save a significant amount of money building its future navy.

To return to the PBO's estimate of the costs of building the CSC, the report notes that the increasing costs were driven by an increase to the weight of the ship and a delay in the schedule. The former had been indicated by a news release from the RCN in the fall of 2020. With respect to schedule, ahead of the release of the PBO report, the Commander of the RCN, Vice-Admiral Craig Baines, and DND's Assistant Deputy Minister, Matériel, Troy Crosby gave an interview to the Canadian Press in which they revealed that the estimated delivery of the first CSC has drifted to 2031.[3] Most project information until that point had specified a first delivery date of the mid-2020s, while the most specific publicly available information, since changed, on the DND Defence Capabilities Blueprint website had indicated a first delivery in 2026. Using those dates, the CSC project has suddenly lost five years. Although the AG did specifically find issue with "schedule management weaknesses" as well as "[i]nadequate risk management tools" the tone of the audit does not capture such a significant shift. Similarly, the 'quad' chart (a detailed outline of the project's status and risks) still available on the DND website for the CSC project showed schedule risk listed as yellow. While it is not totally clear what the colours mean, presumably it works on a stoplight colour schematic, where green is lowest risk and red is highest.[4] On this basis, it is difficult to rationalize a yellow risk rating for the project's schedule only a couple years prior to the announcement of a delay of five years.

The five-year delay suggests that there remain significant unresolved issues with the management of the project, and the governance structure within which it exists. The PBO and AG reports presented a possible impetus to address these issues. As Canada's federal bureaucracy works according to Newton's first law of physics – objects at rest remain at rest unless acted upon by an external force – the lack of significant reaction to the two reports decreases the likelihood of any significant change of approach. If we take the PBO report at face value, the costs of Canada's future fleet are increasing, but at the same time, any reasonable alternative would be just as expensive. This puts a premium on managing the project smartly to ensure Canada retains as much buying power as it can.

Notes

1. Office of the Parliamentary Budget Officer, "The Cost of Canada's Surface Combatants: 2021 Update and Options Analysis," 24 February 2021; and conversation with defence official, 24 February 2021.
2. Parliamentary Budget Officer Claude Giroux, quoted in Canadian Global Affairs Institute, Defence Deconstructed podcast: "Costing CSC," 26 February 2021.
3. Lee Berthiaume, "National Defence Says $60B Warship Project Delayed Until 2030s," The Canadian Press, 2 February 2021.
4. Department of National Defence, "Canadian Surface Combatant," no date given, available at https://www.canada.ca/content/dam/dnd-mdn/documents/quad-charts/csc-quad-chart-en.pdf.

Dave Perry is Vice-President of the Canadian Global Affairs Institute and host of the Defence Deconstructed Podcast.

Warship Developments: Hospital Ships

Doug Thomas

The concept of hospital ships has evolved over the years, starting in the Royal Navy (RN) in the early 17th century. In those times a hospital ship was typically a medium-size vessel taken up from commercial duties, with a surgeon and four surgeon-mates, medical supplies, and space for injured and convalescing sailors. Only two hospital ships were included in the establishment of the RN at that time, a number that has increased during wars and in more recent times. With the increased size and steam propulsion of ships over the past 150 years, hospital ships became more than medical support for the fleet – they were also a means to return wounded soldiers to their homeland and to better-equipped hospitals ashore.

The first internationally recognized use of the term 'hospital ship' comes from the Geneva Conventions and maritime law, including the Third Hague Convention of 1899 and the 10th Treaty of the Hague Convention of 1907. These established restrictions, markings and rules for their use in both World Wars. Suitably marked hospital ships (including lights at night indicating their status) were to be considered neutral and were not to be attacked by combatant forces.

***HMHS** Britannic*

During the 20th century, passenger liners were often requisitioned for wartime use as armed merchant cruisers, troop transports and hospital ships. Their berthing and messing arrangements, size and good turn of speed made them ideal for such purposes.

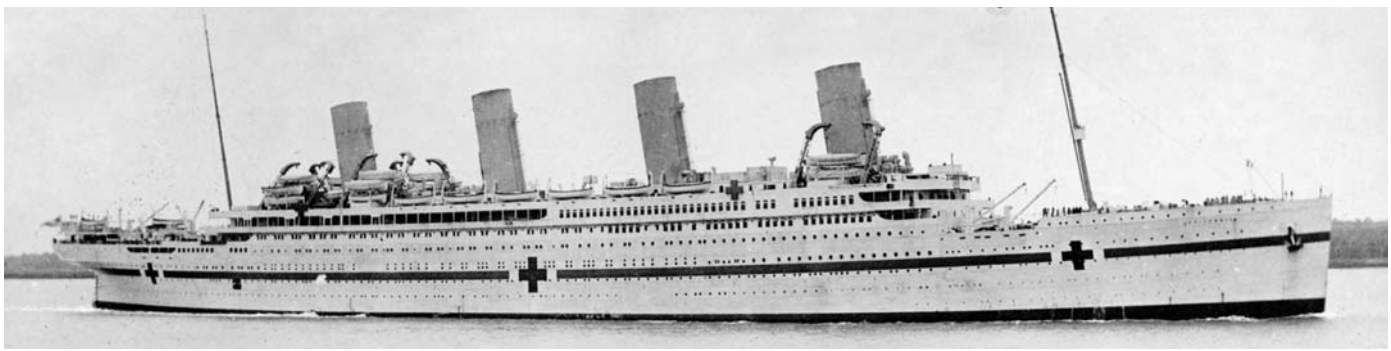
His Majesty's Hospital Ship (HMHS) *Britannic* was a sister-ship of *Titanic*. Her completion was delayed to incorporate the lessons learned in *Titanic*'s 1912 loss, such as improved water-tight bulkheads and sufficient lifeboats for all. She had not been fitted-out as a passenger liner due to these delays, and was requisitioned by the UK in 1915 as a hospital ship – the largest such ship in the First World War. As facilities were constructed on board, the ship was painted white with a green stripe and large red crosses. She deployed to the eastern Mediterranean on six occasions, embarking wounded soldiers and returning them to the UK for treatment and convalescence ashore.

While serving as a hospital ship, *Britannic* had 2,034 bunks and 1,035 cots for casualties. To treat the wounded, a medical staff of about 480 comprising doctors, nurses, and orderlies was on board. This was supported by a ship's crew of 675.[1] Departing Liverpool on 23 December 1915, she reached her base at Mudros, Greece, where some 3,300 casualties were brought on board. *Britannic* then made port at Southampton on 9 January 1916. After conducting two more trips to the Mediterranean, *Britannic* returned to Belfast and was released from war service in June 1916. However, in August 1916 the Admiralty recalled *Britannic* and dispatched her back to Mudros, arriving 3 October.

After returning to Southampton on 11 October, *Britannic* quickly departed for another run to Mudros. On this fifth voyage, the ship returned to Britain with approximately 3,000 wounded. Sailing on 12 November for her sixth deployment, *Britannic* reached Naples after five days. Bad weather detained the ship for a few days but she sailed on 19 November. Nearing the Greek island of Kea on 21 November, *Britannic* was rocked by a large explosion which struck the starboard side. It is believed that this was caused by a mine laid by the German submarine U-73. The ship began to sink by the bow and the failure of some watertight doors to close due to damage and malfunction ultimately led to the demise of the vessel. There were 1,065 crew and medical personnel on board, but as she sank very slowly, all but 30 survived.

***A Canadian Story: HMHS** Llandovery Castle*

Llandovery Castle was one of five Canadian hospital ships in the First World War. On a voyage from Halifax, Nova Scotia, to England, in June 1918 the ship was torpedoed off Ireland by U-86 – the deadliest Canadian maritime disaster of the war. In all, 234 doctors, nurses, members of the Canadian Army Medical Corps, soldiers and seamen



Credit: Allan Green, via Wikimedia Commons

*HMHS **Britannic** as photographed during the First World War.*

Credit: Mass Communication Specialist 3rd Class Pyoung K. Yi, US Navy

USNS ***Mercy*** *(left) and the Chinese hospital ship* ***Peace Ark*** *sail in the Pacific during RIMPAC 2014, the first time RIMPAC has involved hospital ships.*

died in the sinking ship and subsequent machine-gunning and ramming of lifeboats by the surfaced submarine. There were only 24 survivors in a single life-raft. Two officers from U-86 were prosecuted for this atrocity after the war in the Leipzig war crimes tribunal, convicted and sentenced to four years imprisonment – later overturned on appeal. U-86's Captain tried to erase evidence of his war crime in sinking a hospital ship by killing survivors but he fled to neutral territory and was never prosecuted.

In recent years, Battle of the Atlantic commemorations in Londonderry, Northern Ireland, have included a service to honour the memory of those lost in the sinking of *Llandovery Castle*. The names of the nursing sisters who died are listed on the Sailors' Monument in Halifax, Nova Scotia.

USNS Comfort and USNS Mercy

Perhaps the best-known hospital ships in the world today are the US Naval Ships *Comfort* and *Mercy*. They were originally built as supertankers in the 1970s and then converted over the course of nearly three years for the role of hospital ships. They have large flight decks abaft the bridge to accept medevac helicopters from ashore or other ships. *Comfort* (based in Norfolk) and *Mercy* (based in San Diego) are operated by civilian crews, with naval medical personnel from hospitals ashore embarked to provide medical services. In accordance with international conventions, these ships are unarmed.

Their primary mission is to provide rapid, flexible and mobile acute medical and surgical services to support US Marine Corps, Army and Air Force units deployed ashore, and naval amphibious task forces and combat forces afloat. They also provide mobile surgical hospital service for use by US government agencies in disaster and humanitarian relief.

These ships are equivalent to a large metropolitan hospital and capable of handling mass casualties: there are 1,000 beds for patients, including 80 in intensive care units (ICUs). There are 12 operating theatres, a pharmacy, the latest in imaging technology, a burn unit, physiotherapy, a dental unit and many other facilities.[2]

The ships have been forward-deployed during major conflict and have been sent to the sites of major disasters, including to Haiti after the earthquake in January 2010 (USNS *Comfort*) and to the Philippines in the aftermath of Typhoon Haiyan in 2013 (USNS *Mercy*). In 2020 these ships were sent to augment medical resources in New York and Los Angeles in response to the Covid-19 pandemic. The aim was to treat many of the non-Covid emergency cases and thus take pressure off metropolitan civilian hospitals. In New York City the mission was changed to Covid patients as there were few non-Covid emergencies at a time of curfews and lockdowns. Although the ships were not heavily tasked, they were available if needed.

USNS *Mercy* and *Comfort* are normally minimum-manned in their home ports, as their medical personnel are drawn from US Navy hospitals in their home-port region. Given some warning, reserve personnel can be drawn in from anywhere in the country if needed. As well as the response to crisis, they are deployed on a periodic basis to areas in the world where medical facilities are lacking, often with medical personnel from allied states. In addition, large USN amphibious ships are sometimes fitted out with operating theatres for Third World activities such as vaccination programs, cataract operations and Operation Smile to correct cleft palates. Canadian military and civilian medical personnel have been included in some of these missions.

Conclusion

Several other countries also have hospital ships, which are smaller than *Mercy* and *Comfort*, including the Russian and Chinese Navies. They tend to use their vessels as alongside medical facilities in peacetime, although they are available at short notice for disaster response. USNS *Mercy* has operated with the Chinese PLA(N) vessel *Peace Ark* in the Far East.

The Royal Navy does not have a hospital ship at the moment. It was a secondary role for the Royal Yacht *Britannia* for many years but was never exercised. The RFA *Argus* is listed as a Primary Casualty Receiving Facility but it is painted grey, armed, used for other tasks when needed, and therefore not a hospital ship.

What about Canada? Perhaps the Interim AOR *Asterix* could be re-configured after the Joint Support Ships are commissioned to support humanitarian assistance and disaster relief (HA/DR) operations? A worthy role indeed, but she would not be considered a hospital ship unless she met international requirements.

Notes

1. Kennedy Hickman, "World War I: HMHS Britannic," Thoughtco.com, last updated 29 May 2019.
2. This information is available at USNS *Comfort* (T-AH-20) and USNS *Mercy* (T-AH-19) on Wikipedia.

Book Reviews

Red Crew: Fighting the War on Drugs with Reagan's Coast Guard, by Jim Howe, Annapolis, Maryland: Naval Institute Press, 2018, 273 pages, ISBN 978-1-68247-301-6

Reviewed by Katelyn O'Neill

Red Crew is based on author Jim Howe's experiences as an Executive Officer with the US Coast Guard (USCG) in the 1980s. Howe was assigned to a unique set of surface effect ships (SES) in a multi-crewing scheme based in Key West. Four crews manned three different SES cutters, and Howe was part of the team known as Red Crew. This book reflects Howe's personal experiences as well as provides a testament to the anti-smuggling operations the USCG undertook during the Ronald Reagan era.

Howe's time with Red Crew began when he was transferred from New Hampshire to Key West. This transfer presented him with a unique opportunity to work on the SES cutters commissioned to rejuvenate the Coast Guard fleet. Drug smuggling was a rampant and growing problem, and the multi-crewing system addressed this problem by maximizing patrol hours. Each different crew would spend six to eight weeks on a ship and then rotate, one crew working on land at all times. Howe describes his eagerness upon arriving in Key West, and his eagerness to see the ships and get to work tracking down smugglers.

Howe sailed on all three ships for the next two years, gaining experience and forming lasting relationships. Throughout the book, he discusses Red Crew's constant thirst for adventure along with its brilliant way of handling a disappointing result. Howe's first iteration of the book was intended as a Christmas present for friends and family, however, due to the enthusiastic reception it received, he decided to expand on his work with more factual research in order to compile *Red Crew*. Howe enlisted the help of former crew members and a Coast Guard historian to make sure his memory was accurate.

From capturing criminals, seizing drugs, dealing with migrant interdiction and Cuban defectors, working in harsh conditions, participating in military standoffs and search-and-rescue operations, this book exemplifies the work of the US Coast Guard. The exclusive look into the leadership, purpose and friendship demonstrates everything a position with the Coast Guard offered Howe. He acknowledges how his time spent with Red Crew was instrumental in building the rest of his career with the Coast Guard.

Red Crew provides detail into the day-to-day operations, tricky assignments and feats of the USCG. The care that Jim Howe put into sharing his experience with Red Crew is clear. Through intensive research and the tracking down of his former shipmates, Howe keeps the narrative as accurate as possible. When Howe describes a rescue or a drug seizure, readers feel as though they are experiencing it firsthand. Additionally, the photos Howe uses effectively illustrate the operations he describes throughout the book.

Howe's meticulous, detailed account may at times seem redundant. However, this book is well suited to anyone with a keen interest in USCG operations. Howe does not shy away from discussing the dangers and sacrifices associated with a position in the Coast Guard. His respect for the organization, its operations and his fellow shipmates is clearly established throughout the book, providing the reader with an appreciation for the work and life of an officer with the USCG.

The Naval War in the Baltic 1939-1945, by Poul Grooss, Barnsley, South Yorkshire: Seaforth Publishing, 2017, 400 pages, photos/maps, ISBN 978-1-52670-000-1

Reviewed by Chris Buckham

When one thinks of the naval elements of World War Two, the two regions that come immediately to mind are the Atlantic and Pacific theatres. This is for good reason as they were the scenes of titanic clashes never before experienced in the annals of naval history. However, for the Eastern and Northern Fronts, it was the Baltic Sea that held the attention of the Scandinavian, Soviet and German combatants. It was here that the lifeblood of German iron ore, nickel and other key resources flowed from neutral Sweden, where the Germans trained their U-boat crews, safe from Allied bombers and surface combatants, undertook weapons trials from Peenemunde (a town on the Baltic Sea in northeast Germany) and where they were able to support and influence allies such as the Baltic states and Finland in their war efforts. For the Soviets, it was the environment to counter German efforts and spread their influence free from the direct influence of the West, the struggle for Leningrad and a theatre that represented an ongoing threat to their northern flank.

Relatively speaking, little is known/remembered in the West about the struggle that unfolded in the expanse of the Baltic. Grooss has encapsulated the regional war in a way that clarifies and condenses the conflict into a manageable and easily comprehensible format. This work is the result of a many decades-long research project formalized into book form. Originally printed in his native Dutch, the translation into English comes across, at times, as a

little wooden. This does not take away, however, from the superb level of research and detail that is imparted. Replete with hundreds of rare photographs spread throughout the book and superb regional maps, the work is a pleasure to read.

What is fascinating about the region was the close proximity (relatively speaking) of countries with very different political interests. Grooss does an excellent job of relating the high-wire diplomatic acts carried out by Sweden, Finland and Denmark as the war progressed towards its final curtain. The role of Sweden during the war is of particular interest as it acted very much (from a political perspective) as a northern Switzerland; a base for diplomacy and espionage.

An added bonus to his work are the 'explanatory textboxes' that the author adds throughout the book to provide greater understanding of a particular subject (such as mines and how they work, or torpedoes and torpedo-firing methodologies as examples). Without breaking up the narrative, he is able to explain some of these complex systems, thereby adding depth and breadth to the discussion.

Seaforth Publishing has produced a book of very high quality; certainly worthy of the comprehensive and detailed account of one of the lesser known but significant theatres of World War Two. Dedicated historians and casual dabblers alike will find elements of this book to their taste. Grooss may add his name to a growing list of regional authors who have done justice to the memory of those who came before.⚓

Naval Strategy and Operations in Narrow Seas, by Milan Vego, London, UK: Frank Cass Publishers, 2nd Edition, 1999/2003, xviii + 331 pages, index, notes, maps, abbreviations, US$96.87, ISBN (paperback) 0-7146-4425-0

Reviewed by Ambjörn L. Adomeit

The evolving global security environment is forcing militaries across the world to revise their traditional concepts of maritime warfare theory and strategies. Part of this shift is led by technological development, parts are political and/or economic. And, as author Milan Vego highlights, some parts are geopolitical in nature. Vego's second edition of *Naval Strategy and Operations in Narrow Seas* (*Narrow Seas* henceforth) identifies, defines and applies current maritime security environments in contrast to established maritime warfare theory, *circa* the turn of the twentieth century.

Two theories prevailed at the time. In England, Julian Corbett argued that a navy's intrinsic role was to support land-based warfare. In the United States, Alfred Thayer Mahan borrowed from Carl von Clausewitz and argued that decisive maritime battles on the high seas were the strategic and operational goal of all navies.

Considering both perspectives, historical evidence and the evolution of operations and strategy over the decades since, Vego's premise is that there is overwhelming evidence that maritime warfare – not only for centuries, but for millennia – occurs in waters less than 600 feet deep. A Corbettian, Vego asserts that this trend will continue for the foreseeable future, especially since asymmetric maritime conflict between large navies and less powerful navies is increasing in its frequency.

In *Narrow Seas* the author addresses three themes. The first is defining and examining the nuances of narrow and enclosed seas. Second, Vego examines strategic issues such as the geometry of battle spaces in littoral waters, and the role naval bases play in the execution of naval warfare. Third, he investigates and delineates the means by which naval operations can be executed in narrow seas. Vego concludes the book with a discussion of terms such as sea control and sea denial, and how naval bases and naval forces forward the strategic and operational objectives held by land-based armies.

What is a 'narrow sea'? The phrase 'narrow seas' encompasses terms such as coastal waters, confined waters, partly enclosed seas, landlocked basins, littoral waters, and so on. Technically, narrow seas also include enclosed waters: examples of large inland seas include the Great Lakes in North America and the Caspian Sea. Semi-enclosed seas occur exclusively and entirely on continental shelves, and excepting straits, are surrounded on all sides by land. Semi-enclosed seas are also referred to as *pelagic* seas, such as the North Sea. Therefore, 'narrow seas' include specifically enclosed and semi-enclosed seas. Throwing colloquial terms into the definition of narrow seas ends up confusing the technical specificity of the term, a point Vego does go on about.

All of Vego's work comes with a caveat: his research, and his books especially, are not for casual readers, or those with no background in maritime warfare, and *Naval Strategy and Operations in Narrow Seas* is no exception. Researchers from the well-invested armchair historian, through post-graduate level students to strategic and operational analysts will find *Narrow Seas* an excellent volume to read. Lower-year undergraduates and casual readers with little to no formal historiographical instruction will find it a frustrating study. This is not because of Vego's writing style, nor his analytical method. Rather, it is because his books are so densely packed with content that it takes an ordered and prepared mind on the reader's

part to absorb and analyze effectively. This reviewer recommends reading Joshua Tallis' *The War for Muddy Waters: Pirates, Terrorists, Traffickers, and Maritime Insecurity* (Naval Institute Press, 2019) for an easy introduction into the topic of asymmetric warfare in narrow seas and littoral waters, to which selections from *Narrow Seas* may be offered to students.

On balance, *Naval Strategy and Operations in Narrow Seas* is an excellent resource for specialists, but it is a book one will be compelled to read once, take copious notes upon, and subsequently leave on the bookshelf, relying upon said notes to compress Vego's naval theories to usable sections, *sans* the historical examples he uses so profusely.

The Decline of European Naval Forces: Challenges to Sea Power in an Age of Fiscal Austerity and Political Uncertainty, by Jeremy Stöhs, Annapolis, Maryland: Naval Institute Press, 2018, 290 pages, ISBN 978-1-68247-309-2 (e-book)

Reviewed by Colonel (Ret'd) Brian K. Wentzell

Jeremy Stöhs is an Austrian-American defence analyst at the Institute for Security Policy at Kiel University in Germany and its Center for Maritime Strategy and Security. This book analyses the defence policies and naval strategies since the end of the Cold War of 11 European countries. Nine of the countries are members of the North Atlantic Treaty Organization (NATO) and two are non-aligned states.

The author records the transition in defence policies with particular focus on the changes in naval strategies and fleets following the collapse of first the Warsaw Pact and then the Soviet Union in 1991. With the removal of the longstanding immediate naval and military threats to NATO members, and Sweden and Finland, politicians in these states sought immediate relief from burdensome military and naval policies and budgets of the Cold War period.

The author analyses the Cold War defence policies and naval strategies of each country and the transition to the post-Cold War period, with particular explanation of new naval strategies and the impact upon then-existing fleets and the subsequent transition to current forces. The degree of the change differed from state to state, however, in all cases the magnitude of the change was significant. The changes were not simply because of the collapse of the Soviet Union and Warsaw Pact. Each state also experienced significant changes due to demands of citizens and the expectations of youthful populations who had not experienced war or the immediate threat of a continental war. The calls for peace dividends were widespread and heeded by politicians. Defence and naval budgets were accordingly reduced and capabilities scrapped in the absence of the threat of a continental war in Europe.

Stöhs carefully analyses the changes in military strategy and naval policy of each country. From the naval perspective, the resultant naval policy and fleet composition focused less on trade protection and anti-submarine warfare and more upon amphibious operations, power projection, anti-piracy and counter-contraband activities. The result was smaller naval fleets equipped with different technologies for a narrower range of operations.

This book is highly recommended as it reveals the important changes in naval strategy and fleet composition in these 11 European states. Canadian readers should carefully consider these changes and their impact upon Canada's traditional anti-submarine role in the North Atlantic. One applauds Canada's decision to organize the exercise Cutlass Fury 2019 that was conducted off Nova Scotia and Newfoundland. The participation of ships from various European allies, Canada and the United States in an anti-submarine warfare exercise was important to highlight the continuing threat of submarines to commerce and naval operations. The exercise revealed that there is a continuing ability of NATO states to undertake such operations, even in the face of the changes that Stöhs outlines.

2021 Canadian Naval Memorial Trust
Essay Competition

Canadian Naval Review will be holding its annual essay competition again in 2021. There will be a prize of $1,000 for the best essay, provided by the **Canadian Naval Memorial Trust**. The winning essay will be published in *CNR*. (Other non-winning essays will also be considered for publication, subject to editorial review.)

Essays submitted to the contest should relate to the following topics:

- Canadian maritime security;
- Canadian naval policy;
- Canadian naval issues;
- Canadian naval operations;
- History/historical operations of the Canadian Navy;
- Global maritime issues (such as piracy, smuggling, fishing, environment);
- Canadian oceans policy and issues;
- Arctic maritime issues;
- Maritime transport and shipping.

If you have any questions about a particular topic, contact **cnrcoord@icloud.com**.

Contest Guidelines and Judging

- Submissions for the 2021 *CNR* essay competition must be received at cnrcoord@icloud.com by Thursday, **30 September 2021**.
- Submissions are not to exceed 3,000 words (excluding references). Longer submissions will be penalized in the adjudication process.
- Submissions cannot have been published elsewhere.
- All submissions must be in electronic format and any accompanying photographs, images, or other graphics and tables must also be included as a separate file.

The essays will be assessed by a panel of judges on the basis of a number of criteria including readability, breadth, importance, accessibility and relevance. The decision of the judges is final. All authors will be notified of the judges' decision within two months of the submission deadline.

HMCS *Halifax* arrives at the Norwegian naval base Haakonsvern on 5 February 2021 as part of Standing NATO Maritime Group 1.

Credit: Daniel Fatnes, Sjøforsvaret (Royal Norwegian Navy)