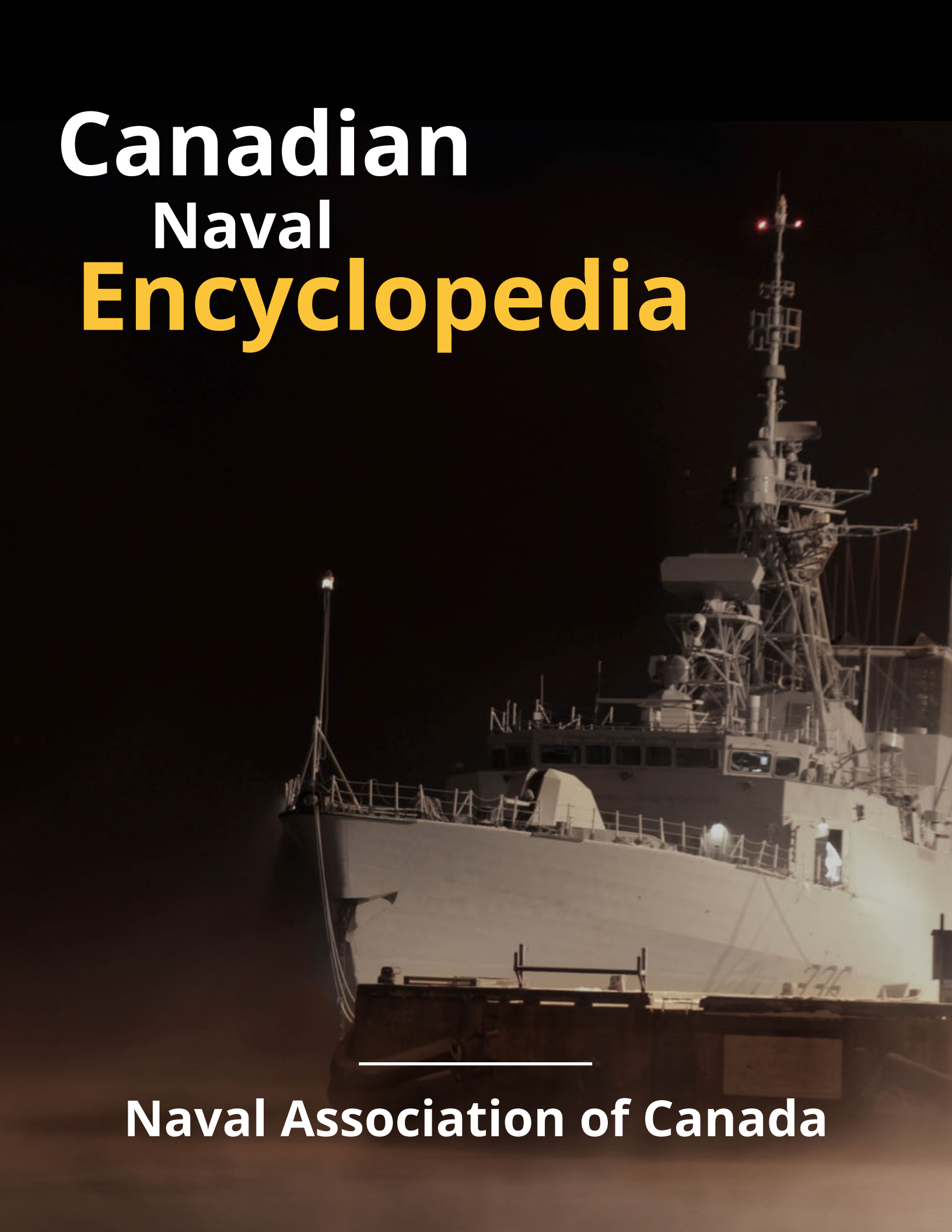
Canadian Naval Encyclopedia



Naval Association of Canada

The Canadian Naval Encyclopedia

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Cover Image: HMCS *Montreal* sits at the dockyard in Halifax, Nova Scotia during the early morning hours on January 14, 2015 (Photo: John Clevett, Formation Imaging Services, CAF)

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Acronyms

ACPA	Association of Canadian Port Authorities
ADM Mat	Assistant Deputy Minister (Materiel)
AIMP	Aurora Incremental Modernization Project
ALSC	Afloat Logistics Support Capability
AOPS	Arctic and Offshore Patrol Ship
AOPV	Arctic and Offshore Patrol Vessel
AOR	Auxiliary Oiler Replenishment
ASLEP	Aurora Structural Life Extension Project
ASW	anti-submarine warfare
ATV	all-terrain vehicle
A2/AD	anti-access/area-denial
AUV	autonomous underwater vessel
BC	British Columbia
CAF	Canadian Armed Forces
CBSA	Canada Border Services Agency
CCG	Canadian Coast Guard
CCGS	Canadian Coast Guard Ship
CDAI	Conference of Defence Associations Institute
CFB	Canadian Forces Base
C4ISR	command, control, communications, computers, intelligence, surveillance, and reconnaissance
CFSS	Canadian Forces Supply System
CIWS	Close-In Weapon System
CLIA	Cruise Lines International Association
CMF	Combined Maritime Forces
CMS	Combat Management System
C-NLOPB	Canada–Newfoundland and Labrador Offshore Petroleum Board
CNR	*Canadian Naval Review*
CODLOG	combined diesel-electric or gas
COMMAR-AIR	NATO Maritime Air Command
COMSUB-NATO	NATO Submarine Command
Corp.	Corporation
COTS	commercial-off-the-shelf
COVID-19	Coronavirus-19
CQB	Close Quarters Battlehouse
CSC	Canadian Surface Combatant
CTF	Combined Task Force
CTG	Commander of the Task Group
C2	command and control
DART	Disaster Assistance Response Team
DEIG	Defence Interest Group
DFO	Department of Fisheries and Oceans
DGMEPM	Director General Maritime Equipment Program Management
DND	Department of National Defence
DNR	Directorate of Naval Requirements
DRDC	Defence Research and Development Canada

DRMIS	Defence Resource Management Information System
EBE	Experimental Bridging Establishment (Royal Engineers)
EDWP	extended docking work period
EEZ	exclusive economic zone
ESSM	Evolved Sea Sparrow Missile
EWP	extended work period
FELEX	Frigate Life Extension
FMAS	Financial Management Accounting System
FMF	Fleet Maintenance Facility
FOC	Full Operational Capability
FONOP	freedom of navigation operation
GDP	Gross Domestic Product
GHG	greenhouse gas
GNWT	Government of Northwest Territories
GPS	Global Positioning System
HADR	humanitarian assistance and disaster relief
HCM/FELEX	Halifax-Class Modernization/ Frigate Life Extension
HMAS	His/Her Majesty's Australian Ship
HMCS	His/Her Majesty's Canadian Ship
HQ	Headquarters
HQ MAR-COM	Headquarters of Allied Maritime Command
IACS	International Association of Classification Societies
iAOR	Interim Auxiliary Oiler Replenishment
IED	improvised explosive device
IMO	International Maritime Organization
IRPDA	Independent Review Panel for Defence Acquisition
ISED	Innovation, Science and Economic Development
ISI	Irving Shipbuilding Inc.
ISR	intelligence, surveillance, and reconnaissance
ISTAR	intelligence, surveillance, target acquisition, and reconnaissance
IT	Information Technology
ITB	Industrial and Technological Benefits
JIATFS	Joint Interagency Task Force South
JOA	Joint Operating Area
JSS	Joint Support Ship
km(s)	kilometre(s)
LCU	landing craft utility
LCVP	landing craft, vehicle, personnel
LM	Lockheed Martin
LNG	liquefied natural gas
MARCOM	Allied Maritime Command
MARLANT	Maritime Forces Atlantic
MASIS	Materiel Acquisition and Support Information System
MCDV	Maritime Coastal Defence Vessel
medevac	medical evacuation
MEXE	Military Engineering Experimental Establishment
mm(s)	millimetre(s)
MMUAS	Maritime Miniature Uncrewed Aircraft System
MPA	maritime patrol aircraft
MPV	Multi-Purpose Vessel
MS	Merchant Ship/Motor Ship

MSOC	Marine Security Operations Centre
MTOG	Maritime Tactical Operations Group
MUSI	Maritime Unmanned Systems Initiative
MV	Motor Vessel
NAD	Naval Annex Dockyard
NATO	North Atlantic Treaty Organization
n.d.	no date
NETE	Naval Engineering Test Establishment
NORAD	North American Aerospace Defence Command
NORPLOY	northern deployment
NRU	Naval Replenishment Unit
NSPS	National Shipbuilding Procurement Strategy
NSS	National Shipbuilding Strategy
NTOC	Naval Tactical Operators Course
NTOG	Naval Tactical Operations Group
OEM	original equipment manufacturer
OFSV	Offshore Fisheries Science Vessel
ONSF	*Our North, Strong and Free*
OOSV	Offshore Oceanographic Science Vessel
PAME	Protection of the Arctic Marine Environment
PC	Polar Class
PJBD	Permanent Joint Board on Defence
PSPC	Public Services and Procurement Canada
QIA	Qikiqtani Inuit Association
RAM	Rolling Airframe Missile
RAS	Replenishment at Sea
RAST	Recovery Assist, Secure and Traverse
RCAF	Royal Canadian Air Force
RCMP	Royal Canadian Mounted Police
RCN	Royal Canadian Navy
RHIB	rigid-hulled inflatable boat
RMDS	Remote Minehunting and Disposal System
RN	Royal Navy
RO-RO	roll-on/roll-off
SAP	Systems, Applications, and Products
SAR	search and rescue
SC	Security Council (United Nations)
SNF	Standing Naval Forces
SNMCMG1	Standing NATO Mine Countermeasures Group 1
SNMCMG2	Standing NATO Mine Countermeasures Group 2
SNMG1	Standing NATO Maritime Group 1
SNMG2	Standing NATO Maritime Group 2
SOCD	Statement of Operational Capability Deficiency
SSE	*Strong, Secure, Engaged*
STANAV-FORLANT	Standing Naval Force Atlantic
STANAV-FORMED	Standing Naval Force Mediterranean
SWIFT	Society for Worldwide Interbank Financial Telecommunication
SWP	short work period
TSRP	Total Ship Reference Point
UA	Umbrella Agreement

UAS	uncrewed aerial system
UAV	uncrewed aerial vehicle
UK	United Kingdom
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
US	United States
USCG	United States Coast Guard
USCGC	United States Coast Guard Cutter
USN	United States Navy
USNS	United States Naval Ship
USS	United States Ship
USSR	Union of Soviet Socialist Republics
USV	uncrewed surface vessel
UUV	uncrewed underwater vessel

Introduction:
Canada as a Maritime State

Across the bottom of the Canadian coat of arms, unfurled at the feet of the lion and the unicorn, lies a banner reading "A Mari usque ad Mare." Latin for "From Sea to Sea," this official motto had its origins in Confederation as an expression of the young Dominion's aspirations, to stretch from the Atlantic and Central Canada across the grasslands of the West to the colony of British Columbia.[1] Today, the official motto could unofficially be expanded to "A Mari usque ad Mare ad Mare," in recognition of the third ocean that frames the nation, the Arctic Ocean. Now, the motto is less aspirational and more a reflection of the country's reality, bounded by three oceans, as a maritime nation.

The oceans and waters of Canada have been central to its inhabitants' lives for millennia. For the Indigenous peoples, the waters not only offered access to fish, shellfish, whale, seaweed, sea lion, sea otter, seal, and beaver – integral sources of food, fur, and oil – but also extensive transportation routes. Through the coastal and inland waterways – and the canoes, umiaks, and kayaks constructed to pass along them – Indigenous peoples accessed gathering and hunting grounds and connected and traded with other communities and nations.[2] Then, European traders and settlers not only arrived by boat but used those same waterways to penetrate the North American continent. Festivals and events continue to celebrate the voyageurs' cultural import, including the ten-day Festival du Voyageur that welcomes over 75,000 attendees to Winnipeg each February.[3]

The water routes were the "highways" and the canoes the vehicles for the Indigenous trappers and European traders alike, facilitating travel and, thus, European encroachment and settlement across the continent.[4] Moreover, the nascent European whaling, sealing, and fishing industries all sought to exploit North America's ocean resources, and the Europeans relied exclusively upon the waters and oceans to transport furs, timber, and fish back to Europe and return with European commodities like guns, cloth, and other luxuries. This exchange, enabled by marine travel, would be integral to the nation's early economic – and political – development.[5] The location today of several major cities like Halifax and Montreal, as well as various other coastal communities, is due primarily to their positioning along these early maritime shipping routes, having grown from key sites of trade and contact.[6] The integrality of this fur trade in Canadian history and in Canada's northern heritage remains clear, for the canoe endures as a symbol of Canada's northernness and maintains a central role in various northern myths in Canada and, thus, in the Canadian identity.[7] A glance at Canada's coins – at the loon on the loonie, the Bluenose on the dime, and the beaver on the nickel – testifies to the endurance of maritime symbols in Canada's cultural identity and national psyche.[8]

An Economy Built on the Seas

Canada, in the 21st century, is sustained by the very maritime and marine trade and transportation routes from which it was born. Many Canadians are divorced from direct and immediate visual reminders of this, concentrated as they are along the nation's southern border with the US. However, in 2021, 5.5 million Canadians (14.9% of us) lived within ten kilometres of the Atlantic, Pacific, or Arctic coasts.[9] As the world's second-largest country, Canada includes 891,163 square kilometres of freshwater (one-fifth of the world's sum, thanks in part to Hudson Bay, the St.

Lawrence Seaway, and the Great Lakes) and the world's longest coastline, at 243,042 kilometres (including the offshore islands' coasts).[10] Fully 5.75 million square kilometres of the Atlantic, Pacific, and Arctic Oceans are also encompassed within the nation's exclusive economic zone.[11] Dotted along its coastline, as of December 2022, exist 845 fishing harbours, 106 recreational harbours, and 560 port facilities. The nation's commercial registered fleet totalled 201 ships in 2022, and 69 registered ferries operated throughout Canada that year.[12]

Canada is, at its economic core, a trading nation. Many goods on which Canadians depend daily are flown, shipped, or trucked in from other nations, and the manufacture of many Canadian products relies on internationally sourced ingredients, materials, and inputs.[13] Canada's 2024 State of Trade Report indicated that trade "represents two-thirds of Canada's GDP [Gross Domestic Product] and exports alone support nearly 3.3 million – or 1 in 6 – Canadian jobs." In 2023, Canada's trade in goods and services reached $965.1 billion in exports and $978.2 billion in imports, including the export of $768.3 billion and import of $770.2 billion in goods alone. Canada's trade-to-GDP ratio – denoting the percentage to which trade accounts for the nation's GDP – reached 67.2% in 2023.[14]

A great deal of the Canadian economy is thus driven by trade, and much of this trade occurs by ship. Goods are almost always cheaper and easier to ship by sea, and, according to the International Chamber of Shipping, around "11 billion tons of goods are transported by ship each year," and approximately 90% of the world's trade is transported by the global shipping industry.[15] Canada is no different. According to the 2024 State of Trade Report, 18% of Canada's merchandise exports were shipped via water (with 40% by road, 19% by pipeline and other, 13% by rail, and 10% by air), while 24% of its merchandise imports arrived by ship (with 52% arriving by road, 12% by air, 9% by rail, and 3% by pipeline and other). These statistics are skewed, of course, by the dominance of the US as Canada's largest trading partner, accounting for $592.8 billion of Canada's goods exports and $484.0 billion of its goods imports.[16] Even here, however, the Great Lakes and St. Lawrence system is integral for trade, serving as key corridors enabling marine trade into inland North America and the efficient and quick transport of cargo between the North American heartland and the Atlantic.[17]

Canada also conducts sizeable and important trade with countries in the Indo-Pacific region (from which Canada's merchandise exports totalled $76.5 billion and its merchandise imports $177.8 billion in 2023), Europe and Central Asia ($54.4 billion in exports, $109.7 billion in imports), Latin America and the Caribbean ($20.6 billion in exports, $70.9 billion in imports), the Middle East and North Africa ($8.4 billion in exports, $7.7 billion in imports), and Sub-Saharan Africa ($2.7 billion in exports, $8.3 billion in imports).[18] For these markets outside of North America, access relies predominantly on marine transit.[19] Here, around 47% of Canada's global trade (apart from the US) occurs via marine transport.[20] This reliance on marine transport for trade means that shipping is responsible for the movement of nearly $151 billion in Canadian exports and $194 billion in imports from international markets, according to 2022 statistics.[21]

Canada's Port Authorities alone handled in excess of 339 million tonnes of cargo that year,[22] and those ports' 2017 performances led the Association of Canadian Port Authorities to conclude that the National Ports System had produced directly over "$17 billion in economic output and $8 billion in GDP." When considered in conjunction with those ports' indirect and induced impacts,

the Canadian Port Authorities had produced an estimated total economic output of $53 billion and annual GDP contribution of $25 billion.[23] As the largest port in Canada and the third-largest port in North America by cargo tonnes, the Port of Vancouver alone facilitates the trade of around $300 billion in goods with 140 to 170 nations annually, estimating itself to handle "$1 of every $3 of Canada's trade in goods outside of North America."[24]

This trade is essential on a variety of levels, beyond its contributions to the Canadian GDP. For consumers, it means job opportunities and accessing – at lower costs – an expanded array of foods, electronics, furniture, clothing, vehicles, and other consumer goods, items that help define Canadians' identities and elevate their standard of living.[25] For businesses, international trade is key to opening new markets, expanding consumer bases, improving economies of scale, and elevating competitiveness and productivity, with trade playing an even more integral role for retailers and businesses that outsource or import their products or that – like the auto industry – rely on internationally sourced intermediate goods like electronic components.[26] The Council of Canadian Academies has aptly summed how industries across Canada rely on marine shipping:

> The metallurgical coal industry in Western Canada and the wheat and canola industry in the Prairies depend on marine shipping for exports to Asia and other markets outside of North America. Atlantic Canada is dependent on marine shipping for exporting oil to the United States and importing it from Africa, the Middle East, and Europe. Manufacturing industries in Central Canada rely on marine shipping to access global supply chains. Intermediate imports are often carried by ship to Canadian firms, later to be re-exported as final goods, often to the United States.[27]

An Economy from the Seas

Though numerous industries across Canada rely on the nation's maritime access to move their products and goods, there are several key industries that depend upon Canada's waters as a *source* of their goods, reinforcing further Canada's maritime status. These ocean industries produce in excess of $30 billion annually.[28] The marine economy in its totality – referring to a combination of the seafood, offshore oil and gas, transportation, tourism and recreation, manufacturing and construction, and public sector industries – accounted for almost $51 billion in GDP in 2023 ($28.071 billion direct, $12.197 billion indirect, and $10.535 billion induced), as well as 445,753 total jobs across Canada (232,644 direct, 119,371 indirect, and 93,739 induced).[29] The significance of the marine economy in 2023 was particularly pronounced in British Columbia (where the sector contributed $18.401 billion in total GDP and 197,905 total jobs), Newfoundland and Labrador (where $12.403 billion in total GDP came from the sector, along with 49,550 total jobs), and Nova Scotia (where around $10.697 billion in total GDP and 106,824 jobs were attributed to the marine economy).[30] For the Atlantic provinces especially, these ocean industries account for significant chunks of the provincial GDPs and job markets. Indeed, a 2021 Statistics Canada report found that the marine sector alone accounted for 30% of the GDP and 16.8% of employment in Newfoundland and Labrador, 13.5% of the GDP and 13.3% of employment in Nova Scotia, and 10.3% of the GDP and 9.3% of employment in Prince Edward Island.[31] Coastal communities particularly sustain themselves through these ocean industries.[32]

Offshore Oil and Gas

Contributing a significant share of the marine economy's GDP in 2023 was the offshore oil and gas industry, which accounted for $8.577 billion in GDP and 15,834 jobs.[33] As of 2024, offshore oil production occurred only in Newfoundland and Labrador,[34] where four projects have accounted for around 4% of the nation's overall oil production and 25% of the nation's conventional light crude oil.[35] Overall, production has been steadily declining since its peak in 2007, and, in 2023, oil production in the province amounted to 73.076 million barrels, valuing $7.9 billion. However, production did increase slightly in 2024 to reach 76.455 million barrels.[36] Still, in 2022, the oil and gas industry represented around 16% of Newfoundland and Labrador's real GDP, contributing 11.4% of the government's revenue in the 2022–23 fiscal year.[37] As of December 31, 2022, 4,242 residents of the province were employed in positions directly supporting offshore petroleum projects.[38]

In addition to its offshore production, this oil and gas industry also primarily relies on Canada's waters to transport the crude oil to international markets and to refineries, given the lack of "crude-by-rail facilities" and crude oil pipelines in Newfoundland and Labrador.[39] Atlantic Canada also receives 96% of the nation's crude oil imports by vessel, as importing crude oil into Atlantic Canada from Europe, the Middle East, and Africa is more economically feasible than transporting it from Saskatchewan or Alberta.[40] Clear Seas concludes "that there are approximately 20,000 oil tanker movements off the coasts of Canada each year."[41] Despite environmental concerns, Newfoundland and Labrador does not appear prepared to abandon the industry yet, projecting an oil production of 82.2 million barrels in 2024.[42] There also seems to be development potential in offshore liquefied natural gas (LNG), with Newfoundland's 2023 budget having allotted $4.8 million towards an assessment of the gas within the Jeanne d'Arc Basin oil reservoirs.[43] Even as environmental concerns grow, offshore energy production continues to generate significant revenues and support thousands of jobs in Atlantic Canada.

Tourism

The tourism and recreation industry was the largest contributor to Canada's 2023 GDP among the marine economic industries, accounting for $11.923 billion in GDP and 158,102 jobs.[44] Marine transportation is central to the tourism industries of many communities in Canada. In numerous coastal communities, small-craft harbours are key to promoting and enabling tourism, as well as supporting recreational boating and yachting.[45] In the Great Lakes region, for instance, such harbours connect people to central attractions like Georgian Bay, Niagara Falls, and the Thousand Islands.[46] The significance of marine tourism to local and provincial economies is even more pronounced when considering the cruise industry. In 2022, the cruise industry – still recovering from the COVID-19 pandemic, as the remaining restrictions were gradually lifted throughout the year – reportedly involved 2,487,000 total passengers (1,595,000 transiting, 453,000 embarking, and 439,000 debarking). The resulting $1.14 billion in cruise line purchases at local destinations, $14 million in ship- and capacity-building expenditures at Canadian shipyards, $27 million in cruise line staff wages, and $464 million in passenger spending at Canadian ports had produced a total output in Canada of $3.435 billion, a total contribution to the GDP of $1.778 billion, 18,536 total jobs, and $849 million in wages.[47] This economic benefit will continue to increase as the cruise industry returns to normalcy following the pandemic.

Indeed, several ports in Canada reported significant rebounds and even record-breaking seasons in 2023. The Port of Halifax alone expected up to 375,000 tourists from 203 cruise ship visits in 2024. This was surely welcome news given estimates that the 2022 cruise industry had resulted in around $136 million being injected into Halifax and the surrounding region, through money being spent at pubs, restaurants, gift shops, galleries, and tours, as well as on vessel provisions and supplies while in port.[48] In Pacific Canada, where the cruise industry was estimated in 2021 to contribute $2.7 billion to British Columbia's (BC) economy,[49] the Port of Vancouver welcomed a record-breaking estimated 1.25 million passengers and 332 cruise ship calls in 2023.[50] In Central Canada, the Great Lakes Cruise Association had forecasted that, in 2023, cruise tourism along the St. Lawrence Seaway and Great Lakes would stimulate Ontario's economy to the tune of $14.3 million generated.[51] Even in Arctic Canada, where the industry is comparably nascent, cruises are key in the territories' tourism and overall economies, generating income from their hiring of Inuit lecturers and expedition team members, contracting of performances and tours, and acquisition of other services from local businesses and communities. For instance, the pre-pandemic 2019 season had seen Nunavut welcoming 4,219 cruise tourists and cruise operators spending $848,394 in 17 communities to provide logistics support, performances, and tours to their passengers.[52] The industry there continues to rebound. In 2023, the Nunavut community of Pond Inlet alone received approximately 3,000 tourists, with the number of visitors expected to increase in 2024.[53]

Seafood

Another notable component of the marine economy in Canada is the seafood sector, which in 2023 accounted for $8.025 billion in GDP and 66,730 jobs, including $4.383 billion in GDP and 29,617 jobs from commercial fishing, $1.144 billion in GDP and 9,978 jobs from aquaculture, and $2.498 billion in GDP and 27,135 jobs from fish processing.[54] Other data from 2023 affirms the importance of the industry, with Canada exporting in excess of $7.6 billion of seafood to 115 countries, making it "among the largest single food commodities exported by Canada."[55] Overall, Canada consistently ranks among the top ten exporters of seafood internationally, ranking fifth in 2021.[56] For some provinces, this industry is more prominent. For Newfoundland and Labrador, international seafood exports in 2023 were valued at around $1 billion, with the 191,873 tonnes of fish landings translating to a landed value of $704 million and the 19,083 tonnes of aquaculture production being valued at $219 million.[57] On the Pacific Coast, BC is consistently the fourth-largest producer of farmed Atlantic salmon globally, with 2023 seeing the province exporting $1.332 billion in seafood, including $436.6 million in Atlantic salmon.[58] In 2022, the prominence of this sector in BC had translated into a 213,342-metric-tonne harvest, the export of $1.55 billion in seafood products to 63 countries, sales of $2.85 billion from primary wholesale and processing seafood, a $720.5 million contribution to the GDP, and 4,810 jobs in the seafood sector.[59] Though commercial fishing occurs on a smaller scale in Canada's Arctic, it remains a notable regional employer and economic contributor. For instance, Nunavut has commercial char, shrimp, and turbot fisheries, offering unique products to global markets, with Baffin Fisheries reporting 2022 harvests of 8,876 tonnes of turbot as well as 7,625 total tonnes of northern shrimp.[60] In 2019, Nunavut Fisheries Association members were reported to have contributed $112 million to Nunavut's GDP and almost 1,000 full-time employment positions.[61] For numerous communities along the Pacific and Atlantic coastlines especially, the seafood industry represents the primary economic activity.[62] Nor does this account for recreational fishing or for fishing's role in traditional Inuit subsistence economies and as a cultural activity.[63]

Shipbuilding

The marine-related public sector, manufacturing and construction (including ship and boat building, as well as ports and harbours construction), and the transportation industry were also significant components of the marine economy. In 2023, they accounted, respectively, for $9.023 billion in GDP and 85,093 jobs, $3.908 billion in GDP and 34,550 jobs, and $9.349 billion in GDP and 85,445 jobs.[64] Combined, these marine industries not only form key sectors of local, provincial, regional, and national economies, but they also are a source of employment for thousands of Canadians.[65] They generate significant tax revenue for the local, regional, and national governments, with Canada's ports producing around $2.1 billion in tax revenues annually, to be reinvested into the nation, provinces, and communities.[66]

Highways

For island and remote communities across Canada, the nation's waters assume further importance by enabling domestic trade and the resupply of communities otherwise inaccessible by road or rail. For islands like Newfoundland and Vancouver Island, for instance, marine shipping enables the accessibility of greater assortments of goods and lower prices than would be available were shipping to rely exclusively on air transport.[67] Such communities also depend on passenger ferries for human mobility, for travel to workplaces and medical appointments, with Unifor reporting that the nation's passenger ferries transport around 22 million vehicles and 55 million people every year, over 180 routes.[68]

However, marine shipping is perhaps most indispensable for daily life and economic development in the Canadian North, where the dearth of widespread rail or road access (or large runways) often makes marine shipping the sole economical method of transporting and accessing goods. There, many communities and defence facilities rely on sealifts from the South to receive dry cargo and bulk materials, including such daily essentials as fuel, food, construction material, and vehicles. According to Clear Seas, ships deliver around "1,400 tonnes of containerized cargo and 214,000 tonnes of non-containerized cargo" to Eastern Arctic communities annually. Iqaluit, for instance, given its lack of its own primary energy production, "relies exclusively on imported fuels" – delivered via sealift – "for all of its energy needs, including electricity generation, heating, and transportation." Given that many communities are only connected to the broader North American and Canadian economies by aviation or marine shipping, such integral goods would be even more expensive and, in some cases, entirely unavailable if marine shipping were not an option. Resource projects, too, rely on marine shipping to receive fuel, equipment, and supplies, in addition to transporting their products to markets.[69] For example, Baffinland Iron Mines Corp., operating the Mary River mine in Nunavut, reported shipping almost 6.1 million tonnes in 2023 by sea. Clearly, marine shipping is indispensable, too, for the territory's mining industry, which constitutes 37% of Nunavut's GDP.[70] In such cases, communities rely on Canada's waters not only for marine industries like fishing and tourism but also for delivering essential goods and supporting key resource industries.

Thus, Canada is a maritime state, and it relies on its waters for conducting trade, fuelling marine industries, supporting other industries, and facilitating the resupply of and human mobility to/from remote, island, and northern communities. It seems likely, too, that Canada's reliance on its waters will only continue to increase in the years to come. Marine shipping generally is expected to

increase, as international trade ramps up in conjunction with global income and population growth.[71] Marine shipping may increasingly supplant other forms of shipping as the method of choice, as companies and governments seek to reduce their environmental impacts and greenhouse gas (GHG) emissions. Notably, there is a burgeoning interest in North America in "short-sea shipping," or the coastal or inland transit of cargo via sea, river, or lake without crossing any ocean. There is great appeal to the increased carrying capacity (and, therefore, economic efficiency) this would enable,[72] as well as the possible reductions in GHG emissions it would produce, given that marine shipping constitutes "the least GHG emission-intensive mode of transportation."[73] Indeed, one study found that the average vessel in the St. Lawrence–Great Lakes Seaway could, on one litre of fuel, transport one tonne of cargo 394 kilometres, compared to 226 kilometres via train or a paltry 49 kilometres via truck. This study also demonstrated that the same tonnage of cargo carried over the same distance would produce 558% more GHG emissions if trucked and 31% more if carried by rail than if that tonnage were moved by vessel.[74] Such shipping could also ease highway traffic, lower highway maintenance costs, decrease road accidents, and lower noise and air pollution. As Canadians grapple with climate change, population growth, increased fuel costs, driver shortages, and highway congestion, short-sea shipping seems poised to increase.[75]

A Growing Industry

Climate change could also translate into increased marine activity in the Canadian North, as the melting of the sea ice further opens the region for fishing, tourism, research, mineral extraction, and shipping activities, including through the Northwest Passage.[76] Such increases are already underway: according to the Protection of the Arctic Marine Environment, the number of unique ships entering the Northwest Passage rose 44% from 2013 to 2019, from 112 vessels to 160.[77] Such increasing activity could have ramifications for safety and security in the Arctic, in addition to elevating the geostrategic and geoeconomic importance of and competition in the region.[78]

Moreover, the industries involved in the marine economy seem to be on the precipice of growth. The tourism and seafood industries could expand, as the cruise industry continues to benefit from increasing standards of living, greater access to transport, and shifts in consumer behaviour,[79] and as the world's growing population and search for more sustainable protein sources elevate the demand for seafood.[80] The offshore energy sector, too, will inevitably see further development, even if and when the world turns away from crude oil. It is expected that Canada will see substantial investment in the ocean's renewable energy, especially in offshore wind and hydrogen production, with assessments pointing to considerable development opportunities on the Pacific and Atlantic Coasts, as well as along the Gulf of St. Lawrence.[81] Bill C-49 (which received royal assent on October 3, 2024) seeks to accelerate the establishment of the offshore wind industry in Atlantic Canada,[82] and Nova Scotia has identified six potential offshore wind development areas and hopes to issue the foremost call for bids for development in 2025.[83] Otherwise, an uptick in the transport of energy products through Canadian waters is anticipated, as the completion of the Trans Mountain Expansion Project increases oil tanker traffic in the Pacific.[84] Similarly, the expanding interest in LNG and the development of projects like the LNG Kitimat export facility and the Woodfibre LNG Project in Squamish will certainly increase the quantity of LNG being transported in Canadian waters.[85] Offshore LNG facilities appear, too, to be on the horizon: in BC, the Ksi Lisims LNG facility is in the works, promising to establish "a floating LNG plant near the Nass estuary at the north end of Pearse Island … capable of producing up to 12 million tonnes of

LNG annually."[86] Evidently, the marine economy is positioned to only grow in importance in Canada.

Risks

Because Canada is a maritime state, heavily reliant on seaborne trade for its economic health and connectivity to the rest of the world, the seas present risk as well as opportunity. Without the world's oceans, the nation's supply chain would be fractured, with extensive ramifications for Canadian consumers and businesses, as well as for Canada's broader economic health and well-being. Canada's sovereignty could also be jeopardized. Thus, Canada's existence as a maritime state exposes it to, and compels its attention towards, both threats *to* the oceans (such as pollution, climate change, and over-fishing), as well as threats *from* the oceans (for instance, criminal activity, piracy, illegal migration, shipping disruptions, and competing naval forces).

Among the potential threats to maritime security originating *from* the oceans, the naval forces of other states pose the greatest and most obvious. Although the culmination of the Cold War had initially seemed to usher in an era of peace and stability, as well as the conclusion of great power rivalry and confrontation, that competition has been reignited. China and Russia, in particular, are increasingly prioritizing the expansion and enhancement of their naval capacities and forces,[87] compelling other states to shore up their own naval forces in response. The consequent competition imperils good order at sea, escalating international tensions and, of course, the potential for destruction in the event that such tensions come to a head.

Current developments in Asia illustrate how these simmering great power rivalries can disrupt the dominance of good order at sea. China has claimed as its own territory Japanese waters in the East China Sea and the entire South China Sea. Other states in the region dispute and challenge both claims. Perhaps partially in response, China continues to push forward with a major program of naval shipbuilding. It launched its third aircraft carrier in 2022,[88] and it has also developed anti-access/area-denial (A2/AD) weapons capable of targeting naval forces seeking to travel through the international maritime regions claimed by China. It has constructed islands and islets in the South China Sea and militarized them with surveillance facilities and runways. It continues its development of electronic warfare equipment able to jam the weapon and navigation systems of ships transiting the region, on which tests started in July 2018.

Although the US Navy has served as a guarantor of freedom of navigation and the freedom of the seas since the Second World War, Chinese military forces cautiously monitor – and China emphatically protests – its freedom of navigation operations (FONOP) near Taiwan and in the South China Sea. Given the region's vast undersea resources, and the trillions of dollars of trade that moves through these seas each year, China's expansive claims and burgeoning naval power are a source of international concern, particularly for Canadian allies in the region. Russia's unprovoked war against Ukraine and campaign of sabotage against the West are further shaking the stability of the international maritime theatre. Russia again has submarines patrolling in the Arctic and the north Atlantic.

In addition to the potential maritime threats posed by the budding naval capabilities of such foreign states as China and Russia, piracy presents another threat to good order at sea internationally. Piracy off the coast of Somalia has, for much of the 21st century, challenged and disrupted trade,

and piracy has also grown to plague trade in the Gulf of Guinea on Africa's west coast. In Somalia, piracy has its roots partly in foreign fishing ships' illegal over-fishing in Somalian waters. Given the lack, for several years, of a Somalian government, and therefore the absence of a Somalian navy or coast guard to patrol the waters, fishermen turned to piracy to address the over-fishing themselves, in a practice that has endured given its immense profits. The piracy in the Gulf of Guinea similarly stemmed from on-land governance issues, namely inequality and unemployment. Though derived from on-land issues, such piracy has tremendous at-sea consequences. The threat of piracy compels tankers and cargo ships to vary their schedules and routes, increase their speed of transit through dangerous areas, elevate their insurance coverage, construct safe rooms, employ security guards, and adopt systems and measures to repel individuals attempting to board their vessels. Though aiming to mitigate their risk, such efforts are expensive, translating into increased shipping rates and, subsequently, increased prices for consumers. These economic ramifications are in addition to the physical threat that piracy poses to vessels and crews transiting the affected regions. Although piracy is typically far from Canada's shores, its impacts on key international shipping routes and, consequently, global trade make it a critical concern for Canada.

Nor is piracy the only criminal enterprise to be increasingly at home on global waters. Crime generally is becoming progressively international, involving the smuggling of weapons, drugs, and people, sometimes over significant distances. The oceans offer attractive routes for this traffic, especially as borders close and travel by land becomes more difficult. Thus, rather than, for instance, drugs crossing from Latin America to the United States, traffickers adopt fast boats and even small submarines to transport drugs across the Caribbean. Such crime threatens the security of all countries, including Canada, exposing residents to the risks of illegal drugs, prohibited weapons, and human trafficking.

Sometimes, domestic and international political tensions can present threats to maritime security and hamper the safety of the seas in adjacent waters. For example, the conflict in Yemen continues to imperil good order at sea given Yemen's location beside the Gulf of Aden and the Red Sea, through which cargo ships and tankers pass while en route to or transiting from Asia, India, the Middle East, and Europe through the Suez Canal. Indeed, the conflict has seen missiles being fired at ships from the shore, with even short-range missiles having the ability to wreak significant havoc and do substantial damage given the narrowness of the maritime area. In another example of the potential ramifications of land-based political conflicts on maritime security, tensions between Iran and the United States prompted Iran to threaten to close the Strait of Hormuz. Given that millions of barrels of oil pass through this strait en route to market, such a closure would be disastrous to the global oil economy and for many energy markets internationally. Amid these tensions, three vessels were attacked in the Persian Gulf in May 2019, and two further ships were attacked the following month. The United States blamed both incidents on Iranian or Iranian-allied forces, although Iran denied the allegations. In addition to presenting very real security concerns for vessels transiting regions around land-based political conflicts, then, such political conflicts also present the possibility of significant trade and shipping disruptions.

When such international conflicts create violence and disorder in impacted countries, they can generate a further prospective maritime threat by producing significant human displacement and migration. In some countries, seized by conflict, chaos, and war, citizens are compelled to flee to and seek shelter in other countries. The same conflicts can demand the evacuation of other

countries' citizens from those war-torn regions – for instance, when the 2006 Lebanon War left thousands of Canadian citizens scrambling to return to Canada. Such evacuations often rely on vessels and marine transit, as they did in 2006. Economic collapses and uncertainty and climate change also drive populations to migrate and force their displacement. For many of these people, the process of relocating to rebuild their lives starts with stepping aboard a boat or ship. While perspectives on and perceptions of such migration vary – from being necessary humanitarian responses to prospective threats to national security – it is undeniable that the oceans are seeing increasing numbers of displaced migrants, as well as elevated human traffic generally. Although Canada has only been minimally impacted on a direct level by maritime migration, the migration issue has sparked significant political upheaval in many European nations, and the resulting instability is of definite concern to Canada as one of their key allies.

In addition to forcing human displacement and migration, climate change can also generate maritime threats to Canadian security. Indeed, as the Earth warms, it is expected that increasingly severe and destructive storms will come off the oceans, potentially creating life-threatening situations for those in the storms' paths. Furthermore, continued global warming also brings the threat of significant ice melt in Antarctica and Greenland. If this occurs, sea levels will rise significantly. This would be devastating for coastal areas, including some of the world's largest and most populous cities, with New York, Rio de Janeiro, Mumbai, Shanghai, Hong Kong, and Tokyo all at risk of being devoured by the sea. According to the United Nations, approximately 40% of the global population resides within 100 kilometres of the ocean, meaning that billions of people would be impacted and potentially displaced by such a sea level rise – including many Canadians. For Canada's northern peoples, their proximity to the coastline brings a further threat from the oceans. Indeed, as climate change opens Canada's Arctic – and the Arctic generally – to further shipping, tourist cruises, and resource extraction, the escalating activity will bring with it a greater potential for environmental spills and serious accidents (particularly since the region remains not fully mapped). This, too, could threaten and imperil the lives and livelihoods of Canada's northern peoples.

With Canada's maritime security facing significant new and evolving threats, including from competing naval forces, piracy, criminal activity, international political conflicts that threaten adjacent shipping activities, rising sea levels, increasingly severe storms, and escalating human displacement, the question becomes how a nation can best address such hazards. For most of these threats, state forces – navies and coast guards – comprise the most effective response, serving to deter, dissuade, and repel other naval forces. As such, Canadian naval forces have participated with North Atlantic Treaty Organization (NATO) allies in, for instance, counter-terrorism operations in the Mediterranean, counter-piracy operations off Somalia, and counter-drug operations in the Caribbean, the latter of which occur annually as part of Operation *Caribbe*. Canadian vessels have sailed to Asia to show the flag during freedom of navigation operations and to support United Nations sanctions against North Korea. They have also engaged in exercises seeking to redevelop and enhance the West's maritime warfare skills, after they were left to deteriorate in the wake of the Cold War. Such vessels and naval forces are moreover critical components of natural disaster responses, enabling the transport of greater quantities of essential equipment – at more efficient costs – than by airplane. Their ability to operate without accommodation and shore facilities, which may be in otherwise short supply following a disaster, is of further value during such responses. Overall, conflict and disorder on international waters

impact – or at least, have the potential to impact – all Canadians, regardless of whether they reside along the coast or inland. There are a variety of potential threats to Canada and Canadians coming from the sea, and Canada's construction and maintenance of a capable and multifaceted naval fleet will be key to its capacity to contend with and address such threats in the years to come.

Defence and Security

There are indications that the Canadian government is increasingly embracing Canada's current and future role – and responsibilities – as a maritime state. The Royal Canadian Navy (RCN) today comprises around 8,400 Regular Force personnel, in addition to 4,100 Reservists and 3,800 civilian employees, crewing and supporting the operations of 12 Halifax-class frigates, 12 Kingston-class Maritime Coastal Defence Vessels, four Victoria-class submarines, six Harry DeWolf–class Arctic and Offshore Patrol Vessels (AOPVs), eight Orca-class training vessels, and over 70 auxiliary vessels.[89] As part of its program to modernize its naval capabilities, Canada announced in June 2024 the commencement of construction activities for the River-class destroyers (the nation's new fleet of Canadian Surface Combatants). These are part of the 2010 National Shipbuilding Strategy, which continues to help "restore our shipyards, rebuild our marine industry and create sustainable jobs in Canada while ensuring our sovereignty and protecting our interests at home and abroad." These functions are part of the Strategy's mission to renew the Canadian federal fleet and develop the national shipbuilding industry in support of the Canadian Coast Guard (CCG) and RCN.[90]

Furthermore, *Our North, Strong and Free* (*ONSF*), Canada's 2024 defence policy, includes several pledges to enhance Canada's naval capacities, including to explore the expansion and renewal of its submarine fleet, secure specialized maritime sensors to assist ocean surveillance and monitoring, and investigate options for acquiring long-range sea-launched missiles.[91] Since the release of *ONSF*, the Canadian government has also solidified its pledge to acquire "up to" 12 conventional submarines.

The CCG, meanwhile, operates over 120 vessels, including icebreakers, buoy tenders, search and rescue lifeboats, patrol vessels, science ships, and air cushion vehicles/hovercrafts.[92] It will also benefit from the National Shipbuilding Strategy. The CCG has already seen the delivery of three Offshore Fisheries Science Vessels (CCGS *Sir John Franklin*, CCGS *Capt. Jacques Cartier*, and CCGS *John Cabot*), expects to receive six icebreakers, and plans for the construction of two long-delayed polar icebreakers.[93]

Governance

A complex ecosystem of policies, investments, and legislation also affirm Canada's increasing prioritization of its maritime sectors and regions. For instance, the Government of Canada's 2024 Blue Economy Regulatory Roadmap outlines the steps it pledges to take to support economic growth and innovation in the Canadian oceans, with a focus on sustainable fishing practices and gear, ocean technology, marine spatial planning, maritime autonomous surface ships, and marine environmental protection and renewable energy.[94]

Some provinces are developing their own marine transportation strategies, such as Ontario's 2023 *The Future of the Great Lakes Economy: Ontario's Marine Transportation Strategy*, which identifies itself as "the blueprint to grow Ontario's marine transportation network over the next 10

years."[95] Similarly, the Government of Canada's ongoing transportation plan, *Transportation 2030*, includes waterways, coasts, and the North as one of its five key themes, aiming to "[b]uild world-leading marine corridors that are competitive, safe and environmentally sustainable, and enhance northern transportation infrastructure." Associated investments have been made under the Oceans Protection Plan (a $1.5-billion plan launched in late 2016 seeking to "improve marine safety and responsible shipping, protect Canada's marine environment," and "offer new possibilities for Indigenous and coastal communities") and the National Trade Corridors Fund (which has involved $2.3 billion in investments from 2017/18 to 2027/28 "to strengthen Canada's trade infrastructure," including its waterways and ports).[96]

Northern Canada in particular is welcoming federal investment into marine infrastructure, including the opening of a harbour at Pond Inlet in 2022 and Iqaluit's deep-sea port in 2023. There are also plans for another port in Nunavut's Qikiqtarjuaq, which proponents describe as promising to transform the territory's offshore fishery and boost tourism.[97] Similarly, billions are being invested into marine shipping on the St. Lawrence Seaway and Great Lakes.[98] For instance, the Port of Windsor is welcoming federal investments for the expansion and improvement of its grain terminal to promote its grain exports, as well as "for a massive cargo terminal infrastructure expansion and shoreline protection project." The latter project is expected to shift a great deal of the goods transport in the region to ships and thus reduce local highway congestion and pollution.[99]

Moreover, one of the five Global Innovation Clusters that continues to receive federal investment is the Ocean Supercluster, which describes itself as "an industry-led, national ocean cluster that brings together startups, scaleups, as well as mature organizations from coast-to-coast-to-coast." Its mission is to promote the "growth of Canadian's ocean economy, deliver collaborative solutions, build a strong global ocean brand, connect ocean communities, and build Canada's diverse ocean workforce."[100] The Supercluster's *Ambition 2035* report documents its prioritization of energy, sustainable seafood (including growing the sector to $25 billion by 2035), marine transport, ocean technology, tourism and recreation (with the ambition to develop Canada's marine tourism industry by 2035 to $30 billion), and the public sector. Together, these priorities target the "shared ambition to grow Canada's ocean economy to $220 billion by 2035" and help Canada "realize its full potential as an ocean nation."[101]

On a more global scale, Canada has ratified or is a party to the majority of international shipping conventions and maritime governance treaties, including the United Nations Convention on the Law of the Sea and the International Convention for the Prevention of Pollution from Ships.[102] Canada has served on the International Maritime Organization (IMO) Council since 1959, after being a founding member and the first nation to ratify its Convention in 1948. As such, it participates directly in the agency that is "responsible for the safety and security of international shipping and the prevention of marine pollution by ships," and it partakes in and influences high-level discussions related to marine security, safety, and environmental protection.[103] Its priorities at the IMO, according to a Transport Canada aide-mémoire, include "Protecting the environment and reducing greenhouse gases," "Protecting polar waters and Arctic cooperation," and "Supporting the wellbeing of seafarers."[104] Canada has further enshrined these standards into legislation like the *Canada Shipping Act, 2001*, and the *Arctic Shipping Safety and Pollution Prevention Regulations*, seeking to incorporate IMO codes like the 2014 Polar Code (or *International Code for Ships Operating in Polar Waters*) into Canadian law.[105] Other legislation

developed by Canada to govern its maritime regime include the *Arctic Waters Pollution Prevention Act*, *Oceans Act*, and *Fisheries Act.*[106]

Climate Change

Canada is undeniably a maritime state. Framed on three sides by oceans, and with a history and national identity heavily rooted in sea-based and riverine trade, Canada continues to sustain itself and grow thanks to its significant marine networks, thriving ocean economies, domestic resupply sealifts, and the support that the shipping industry provides to a plethora of other key regional and national industries. The Canadian government has not always embraced this identity in its policies and approaches to defence; however, the country today is placing greater priority on developing, supporting, and regulating activities in and on Canadian waters.

While its connection to the world's oceans provides enormous benefit to Canada, its reliance on these waters has also made the country vulnerable to the impacts of climate change. As the world warms, potential marine impacts include changes in ocean chemistry (including in temperature, salinity, acidification, and oxygen depletion), rising sea levels (producing risks of erosion, storm surges, and coastal flooding and inundation), the increasing prevalence and severity of extreme weather events, and cryospheric changes (including permafrost melt, coastal erosion, and sea ice changes). Such changes can, in turn, impact marine shipping, fishing, and tourism, even wreaking havoc on coastal and port infrastructure through, for instance, shoreline erosion and the elevated corrosion of infrastructure.[107] The fishing industry in particular can expect dramatic challenges, as fish populations migrate northward (changing the mix and abundance of species), larger waves and more severe storms challenge fishers, and changes to ocean chemistry – with the oceans' absorption of carbon dioxide – corrode the exoskeletons and shells of crustaceans and molluscs, potentially exacerbate the impacts of algal blooms, and perhaps alter the mortality rates among younger fish.[108]

In the Great Lakes and St. Lawrence, climate change has contributed and will continue to contribute to warmer air and water temperatures. This can increase evaporation and lower water levels, with the potential to complicate safe navigation in shallower regions and necessitate lighter loads to prevent running aground, in turn producing shipping cost hikes.[109] Such disruptions due to climate change are already being seen. Extreme drought in the Northwest Territories produced record-low water levels, especially in the south, in 2024. As a result, the territorial government had to reroute some cargo shipments to avoid the exceptionally low water levels on the Mackenzie River, and barge deliveries were cancelled to the communities of Tulita, Norman Wells, and Fort Good Hope due to the unnavigability of some sections of the Mackenzie.[110] Climate change can thus pose dramatic disruptions to ocean industries, regional and national supply chains, and marine transportation and coastal communities generally. This is a global threat with which Canada must contend, as a maritime state.

Conclusions

As a nation blessed with the longest coastline in the world and easy access to three oceans and the world's maritime trade routes, Canada's security and prosperity are inextricably connected to the sea. For generations, the Royal Canadian Navy has worked with partners and allies to guard the sea lines of communication to maintain North America's link to Europe and keep open global trade

routes for the globalized economy. Much of this activity takes place far from shore and out of sight and mind for most Canadians. However, it is this constant presence and activity that underpins the Canadian way of life.

Understanding how the RCN performs these tasks and how it impacts life in Canada is naturally essential to maintaining and strengthening the nation's position on the seas. This encyclopedia is crafted from the Naval Association of Canada's Briefing Note series to summarize the most important elements of Canada's maritime security to serve as a reference and source of information for anyone seeking to learn more about what keeps Canadians prosperous and secure.

I. Shipbuilding and Procurement

Naval Shipbuilding in Canada

Canada is currently undertaking the revitalization of its federal fleet. The decades-long project, involving the investment of billions of dollars, will see the renewal of the Royal Canadian Navy's (RCN) and Canadian Coast Guard's (CCG) aging fleets, modernizing their vessels and enhancing their ability to fulfill the multivarious roles and responsibilities required of them in an increasingly complex geopolitical and geostrategic climate. In doing so, the National Shipbuilding Strategy (NSS) will also see the continued revitalization and renewal of the Canadian shipbuilding industry, which had largely atrophied after years of no significant vessel construction contracts. Despite the progress that has been and that continues to be made under the NSS, criticism endures surrounding the seemingly ever-increasing costs of the construction projects, as well as the apparently recurring delays. However, a contextualization of these increasing costs and delays – and why they inevitably occur – is warranted, as they are issues that will confront most countries in their procurement processes.

Increases in the projected cost of a ship as its procurement process progresses often elicit ire from critics. However, they are also inescapable. A primary reason for such increases is that the initial figure that a government announces as the expense for a ship's procurement is always merely an estimate. Evaluating at such an early stage the overall cost of a ship is extraordinarily difficult, if not entirely unfeasible. According to naval engineer David Peer, "Initial cost estimates for a purpose-designed ship typically quote an error of ±40%, so the risk of under- or over-predicting cost with early estimates is significant."[111] Indeed, acquiring sufficient data to inform an accurate cost estimate is challenging. In Canada, not only is information from domestic production out of date, if not entirely unavailable, given that no major warships had been (at the time of the National Shipbuilding Procurement Strategy's inception in 2010) constructed in Canada for over two decades,[112] but acquiring information internationally can also be problematic. Some nations are not willing to share details of their procurement expenses, and even if they were willing, differences in the vessels as well as in the costs for materials, technology, and labour would all minimize the usefulness of such international comparisons in formulating an estimated cost in Canada. Nor is utilizing comparably sized commercial cargo vessels to estimate costs a feasible alternative. In contrast to naval ships with their large crews (the size of which may, of course, change as uncrewed ship technologies advance), commercial vessels operate with small crews and with a focus on maximizing their cargo space. Naval ships, moreover, have significantly more complex communication, weapon, and propulsion systems than their commercial cargo counterparts. Warships are denser and heavier, too, given their need for greater "survivability."[113] As such, the initial expense a government cites for a procurement project is invariably an estimate, particularly given the difficulty in securing adequate data from comparable vessels to inform the estimate.

Also invariably, this cost changes and evolves over time. A more formal budget emerges as decisions are reached about the ship's construction and specifications, and this budget oftentimes encompasses more than simply the cost of constructing the ship itself. Instead, the budget will comprise, for instance, long-term service and/or maintenance contracts for the vessel, which often entail sizeable expenses. Moreover, various factors utilized to develop the initial estimate will shift over time. Steel prices, interest rates, and foreign exchange rates (which impact components sourced internationally) will all fluctuate and vary. As such, the price of a particular element will

be heavily influenced by the time at which it is purchased, variances that are impossible to predict at the time of the initial cost estimate.

Given that the design and construction of a naval ship is an inherently complex process involving a variety of naval technicians, engineers, and designers from numerous manufacturers, acquiring quotes from each individual company for each individual planned component would be too extensive and arduous a process to be feasible. As such, the initial estimated design cost of a vessel is often derived from the weight of the projected vessel. In the absence of exact details about the specific characteristics and capabilities of the vessel being procured, the size of the vessel can often be compared to preexisting ships for this initial design costing. As Peer indicates, "Historical information from a known design and cost data for selected major systems and equipment can provide first approximations of ship cost for a series of concept designs that meet the capability requirement."[114] Of course, this system is not without its faults. Oftentimes, the hull, the component on which this method is based, is not the costliest component of a ship. For instance, in the United Kingdom, "systems represent the biggest percentage of the price of a warship – 70% compared to 30% for the hull."[115] Though these percentages may vary between countries, the general trend is the same. It is the technology *inside* the vessel that bears the most significant impact on its price. Unfortunately, a government is not and cannot necessarily be aware in the beginning phases of a procurement project, when it develops its cost estimate, what specific technology will be incorporated. Decisions as to the particular capabilities of a vessel are only made following discussions with the Coast Guard and/or Navy. Moreover, because vessels in the CCG and RCN are intended to have decades-long lifespans, often being used for up to 40 years, there is a tendency to equip them with the most modern technology available at the time of construction, which often delays those decisions. Consequently, many of the components that most influence the cost of a vessel's procurement are determined and finalized as the procurement process proceeds, leading to a necessarily evolving cost estimate and inherent vagueness in the initial estimates.

The location of a vessel's construction is a further consideration that significantly impacts the cost of its procurement. A ship can either be purchased "off the shelf" (for instance, purchasing an existing ship) or constructed in Canada. For a domestically produced ship, a design would necessarily be sourced from industry either within or outside of Canada, since the RCN's design offices have long been closed and the Canadian government therefore no longer possesses the ability to design vessels. For some people, efficiencies of scale and labour costs make procuring a vessel internationally an attractive prospect, with the argument being that Canada could secure vessels more expediently and inexpensively if they were constructed or purchased from elsewhere. While this debate often resurfaces, many others perceive it as a false debate.[116] It is a fact that the vast majority of states with mature navies construct their own naval ships and possess a strategic alliance of some sort with domestic shipbuilders. Therefore, the United Kingdom secures its vessels domestically from BAE, Germany from B&V, and France from The Naval Group/DCNS. Even in the United States, where shipyards are private, certain shipyards specialize in particular types of vessels. Most of Canada's allies are of the stance that protecting their long-term national security interests requires possessing the ability to construct, repair, upgrade, and sustain their own naval vessels. Due to these sovereignty considerations – as well as the desire to create jobs and promote industries within their own borders – the national shipbuilding industries in these states have no competition for contracts for coast guard and naval acquisitions. Such considerations strongly deter a state like Canada from purchasing a naval ship "off the shelf."

Costs also typically increase throughout the vessel's construction as delays are encountered. Expenses increase in tandem with rising labour costs and the prices of raw materials. Fluctuations in inflation – which is generally higher for the defence industry than the broader population – also impact the initial budget.[117] Indeed, thanks to inflation, the value of the budget initially allotted to a project deteriorates as the vessel gradually takes shape, with Peer summarizing that although "[t]he time value of money is often ignored in the discussion," a product budget "buys less" with each year it "sits unused."[118] Such delays in procurement, then, combine with the gradual selection of specific ship components, delineation of long-term service/maintenance contracts, and changes in raw material, interest, inflation, labour, and foreign exchange rates to produce procurement budgets that inevitably evolve and increase as the vessel moves closer to completion.

However, such delays are often unavoidable. Overall, the procurement of a vessel in Canada is a lengthy and time-consuming process. The process begins with the government's recognition of a capability gap or that a vessel is either at or near the end of its useful life. The government then decides the capabilities it desires in the new vessel, issues a request for proposals for the vessel's design, cautiously examines and assesses the resulting bids, and negotiates with the selected shipyard to confirm the details of the procurement. The design itself can move through several phases, including a design study, feasibility study, preliminary design, and contract design, before a detailed design is finalized. Only then can the actual construction activities commence.[119] Therefore, acquiring a vessel is not an immediate or expeditious process. As Peer explains, "the time it takes to buy a warship must include all design activities as well as construction. If you had to wait for your car to be designed and then built, car buying would also be a long process."[120] However, that this process is such an extended ordeal is not necessarily negative or undesirable, given the exorbitant sums of taxpayers' money involved and the government's desire to minimize, as much as feasible, any opportunity for lawsuits or disputes emerging from unsuccessful bids. The price of this caution is, of course, a slower process of procurement.

The National Shipbuilding Strategy, formerly known as the National Shipbuilding Procurement Strategy (NSPS), intends to not only revitalize the fleets of the RCN and CCG but also to rejuvenate and reinvigorate the Canadian shipbuilding industry. Historically, the industry has waxed and waned in a boom-and-bust cycle: the government would order a vessel, the shipyards would be engaged temporarily in the production of that vessel, and, following its completion, the shipyards would lose capability and workers in the years and sometimes decades before another ship was ordered. A core objective, then, of the NSPS/NSS was to shift the domestic shipbuilding industry away from this cycle by developing a project that would ensure the continual construction of ships over a prolonged period of time. At the Strategy's commencement, then, there was necessarily some delay while the contracted Canadian shipbuilders modernized and equipped their facilities in preparation for their awarded construction projects. A similar complication arose from the personnel requirements to undertake the construction work. Since Canada had not seen a major naval shipbuilding project for two decades, there were few people with experience or expertise in the management of a project of such scale. Hiring and training personnel at the shipyards – and cultivating experience in the workforce – both required time. This, too, was a source of concern and initial delay.

The procurement of a warship is furthermore a lengthy process due to the complexity of the vessel itself. The design considerations are numerous and multifaceted. A warship is a vessel that, in addition to floating, must be capable of moving and fighting. As such, designing and constructing

such a vessel demands careful attention to such features as the hull's security and strength, the structural stability and balance required to float, the propulsion system needed for movement, and the vast array of weapon systems, communication systems, and sensors integral for fighting.

Moreover, crewing the vessel comfortably and safely offers another element demanding meticulous consideration. In Canada, too, there is the further challenge of ensuring that a vessel is adequately "Canadianized," or that it addresses the various specific elements required for operations in the Canadian clime and under Canadian legislative and demographic realities. For instance, Canada has particular power supply settings and standards, stringent rules about the security of weapons aboard ships, and requirements for both air conditioning and heating in vessels (a consideration inevitably not shared by navies based in more temperate climates). Further rules govern the space provided for crew members, and policies exist regarding the accommodation of women aboard ships. Canadian vessels must be able to operate in a sometimes unforgiving and cold climate. They must also be equipped to contend with ice in the water, as well as the ice that may form on a vessel in cold weather. Canada moreover has specific rules dictating the handling of wastewater. All these elements – as well as numerous others – are considerations that must be acknowledged and accommodated when designing, constructing, or adopting a vessel for use by the RCN or CCG. Ensuring a design's compliance with and incorporation of all requisite elements inevitably lengthens the procurement process. Such rules, regulations, and requirements applying to Canadian ships may differ from those of other states, making simply purchasing a naval vessel "off the shelf" a more complicated – and perhaps less feasible – option than may be expected.

Thus, shipbuilding is a protracted and complex process, for which the initial cost estimated is typically far surpassed by the actual cost of procurement. Both facts are unavoidable. The initial cost estimate increases as the specifics of the vessel are determined, maintenance and service contracts are reached, and delays are experienced. Fluctuations in raw material prices, labour costs, and interest, foreign exchange, and inflation rates all compel further adjustments to the procurement costs. The process of acquiring a vessel, between the announcement of its construction and its entry into operations, is lengthy, too, given the intricacies of the ships being constructed and their need to incorporate and satisfy a variety of Canadian regulations and standards. There was also the need, in Canada's case, to modernize the shipbuilding facilities and secure an adequately trained workforce before construction projects under the NSPS/NSS could commence. However, it warrants mention that increasing costs and delays in procurement are not an exclusively Canadian phenomenon but rather are experienced in many countries undergoing procurement processes. Furthermore, while the procurement process in Canada inevitably encountered growing pains in the first decade of the NSPS/NSS, the continuance of construction under the Strategy will mean that personnel will continue to develop experience, shipyards will continue to improve their effectiveness and efficiency, and the government will continue to improve its cost estimations.[121] This mounting experience for all actors involved in the NSS should lead to less acute cost increases and shorter procurement timeframes, although constructing naval vessels will remain a tedious, drawn-out, and expensive process.

The National Shipbuilding Strategy (NSS)

Amid the Canadian government's budget cuts and cost-cutting measures of the late 1990s and early 2000s, the fleets of the Royal Canadian Navy (RCN) and Canadian Coast Guard (CCG) suffered a period of aging and deterioration. In response to the clear need to modernize the fleet, the government of Prime Minister Stephen Harper announced the National Shipbuilding Procurement Strategy (NSPS) in June 2010. The Strategy endured through the 2015 transition of federal power, with the election of Prime Minister Justin Trudeau. Now called the National Shipbuilding Strategy (NSS), the program is a decades-long process and commitment that will, once complete, have seen billions of dollars invested into the renewal of both Canada's shipbuilding industry as well as its federal fleets.

The NSPS had five high-level objectives. In addition to revitalizing the Canadian shipbuilding industry and rebuilding the RCN's and CCG's fleets, it also pledged to create long-term strategic relationships with two Canadian shipyards, ensure the realization of those shipyards' commitments to the defence industrial objectives, and foster economies of scale to maximize the project's value for taxpayers. In doing so, it would direct its focus on three elements of the federal fleet: combat vessels, non-combat vessels, and small vessels with displacements of under 1,000 tonnes. The latter category would have its own competitive bidding process, with the contract(s) for the construction of the more than 100 small vessels (valuing at $2 billion overall) to be offered and issued to shipyards not affiliated with those ultimately selected to construct the larger vessels. For the larger vessels, there were five prospective shipyard bidders across Canada that would conceivably be of sufficient size and capability to put forth proposals, from which two bids – and two shipyards – would be selected. The ensuing process was, for many, a surprisingly successful Canadian procurement story. The process was transparent, open, fair, and devoid of political interference and engagement. What the process lacked, however, was adequate and effective communication, particularly on the part of the Canadian government. It failed to sufficiently inform Canadians that the selection of shipyards and issuance of contracts was only an initial step in a decades-long process, or that the initial cost estimates for individual projects were just that – only estimates, subject to change. The government continues to struggle with conveying these messages to Canadians, exposing it to broad and pervasive criticism that its procurement process suffers from widespread cost overruns and schedule delays that are preventing the vessels' timely construction and delivery to the RCN and CCG.

In October 2011, the Canadian government declared its selection of the two shipyards that would shoulder the responsibility for completing the large ship projects, with the initial near-term work estimated at over $30 billion. Irving Shipbuilding Inc. (ISI) of Nova Scotia would undertake the construction of the combatant ships, namely the Canadian Surface Combatants (CSC) [now River-class destroyers] and six to eight Arctic and Offshore Patrol Ships (AOPSs) – the largest component of the NSPS. Meanwhile, British Columbia's Seaspan Shipyards would construct the non-combat vessels, including three Offshore Fisheries Science Vessels (OFSVs), one Offshore Oceanographic Science Vessel (OOSV), two (possibly three) Joint Support Ships (JSSs), and one polar icebreaker. This announcement was followed, in February 2012, by the government's signing of "Umbrella Agreements" (UAs) with both shipyards to delineate their working relationship, as well as the projects' administration. Commitments in hand, ISI and Seaspan both commenced significant upgrades to their shipyard facilities, modernizing their technology and equipment to

elevate their capacity and efficiency – a crucial task, since it had been many years since the shipyards had undertaken major projects. As those upgrades advanced, work progressed on the ships' designs.

At Seaspan, construction began first on the three OFSVs destined for the Coast Guard and the Department of Fisheries and Oceans (DFO). The first, CCGS *Sir John Franklin*, was launched in December 2017 and delivered to the CCG on June 27, 2019, following its sea trials, making it the first large vessel to be completed and delivered under the NSS. CCGS *Capt. Jacques Cartier*, the second OFSV, was delivered to the CCG in December 2019, while the third, CCGS *John Cabot*, was handed over in October 2020. The OFSVs thus had the distinction of being the first complete class of ships to be constructed under the NSS.

Seaspan's work on the JSSs, OOSV, and polar icebreaker is ongoing. The design for the JSSs – the replenishment support ships for the RCN – was announced in June 2013, following the selection of the German Berlin-EGV-class design, with adaptations for Canadian operational needs. Initially to be named HMCS *Châteauguay* and HMCS *Queenston*, the vessels were re-designated as the future HMCS *Preserver* and HMCS *Protecteur* in 2017 following the federal transition of power. Though the vessels were initially intended to become fully operational in 2019, these plans have been deferred on several occasions, with construction of the early blocks only beginning in June 2018, while the third OFSV was being built.

In early 2019, the Canadian government decided to adjust the construction sequence at Seaspan, prioritizing the construction of the first JSS, given the RCN's urgent need for support vessels. This would be followed by the singular planned OOSV and thereafter the second Protecteur-class JSS vessel. Despite delays, there has been progress on the future HMCS *Protecteur*. The initial "grand-block" (formed by the joining of four large blocks) was assembled in November 2019, the keel was laid in January 2020, and the final bow unit was connected to the remainder of the hull towards the end of 2021, thus completing the vessel's forward end. The engine room capping was concluded in March 2022, its first superstructure block was raised in mid-April 2022, the mast section had been hoisted by crane by March 2023, and an April 2023 announcement revealed that the hull was now assembled and in one piece. According to a May 2024 update from Seaspan, the final significant structural block installation was completed in the autumn of 2023, with construction then focusing internally on the installation of piping and cables.[122] HMCS *Protecteur* was ultimately launched in December 2024.[123] HMCS *Preserver*, the second JSS, is expected to be completed by 2027, after its construction commenced in May 2022.[124]

The initial plans had envisioned Seaspan also constructing a heavy or polar icebreaker, to be designated CCGS *John G. Diefenbaker*. However, the federal government removed this icebreaker from Seaspan's planned work schedule in June 2019. In compensation, Seaspan was granted the opportunity to construct an additional 16 Multi-Purpose Vessels (MPVs) for the CCG, following the completion of the Navy's JSSs. The following February, the Government of Canada issued a call to shipyards to compete for the opportunity to construct the polar icebreaker, with ISI, Seaspan, and Quebec's Chantier Davie all responding with interest. Finally, in May 2021, the government revealed that two – rather than the initially planned one – heavy icebreakers would be constructed, one at Davie and the other at Seaspan. The agreements were signed in April 2023, and though the intent is for the icebreakers to be available by 2030, it is unclear whether this will be feasible.

In August 2019, the government launched a new competitive process for the construction of an additional six medium icebreakers for the CCG. The NSS's participants would therefore be expanded to include a third shipyard – propelled, in part, by political interference and pressure on the federal government to incorporate a third shipyard into the program. Chantier Davie pre-qualified and thus joined the NSS as the contractor responsible for the production of medium icebreakers. In the interim, Chantier Davie converted three medium icebreakers to supplement the CCG's existing fleet. Thanks to this further component of the NSS, the CCG has welcomed CCGS *Captain Molly Kool*, CCGS *Jean Goodwill*, and CCGS *Vincent Massey*, the latter of which was delivered in 2022 and commissioned the following year.[125] As previously mentioned, Chantier Davie will also construct one of the NSS's heavy icebreakers, intended for availability by 2030.

Meanwhile, on Canada's East Coast, Irving Shipbuilding set to work on building the Harry DeWolf–class AOPSs. Initially, only five of the planned six to eight ships were to be constructed, until the government added a sixth vessel in the autumn of 2018 and, in May 2019, announced the addition of another two vessels, for the CCG. Irving delivered its first AOPS, HMCS *Harry DeWolf*, to the RCN on July 31, 2020, with the vessel being commissioned in June 2021 following sea trials. Two months after commissioning, it embarked on its first major operational deployment, sailing from Halifax through the Northwest Passage before proceeding southward along the Pacific Coast and through the Panama Canal, successfully completing a full circumnavigation of North America with its return north to Halifax. The second AOPS, HMCS *Margaret Brooke*, was launched on November 10, 2019, completing its sea trials before being handed over to the RCN and commissioned in October 2022. HMCS *Max Bernays*, the third Harry DeWolf–class vessel, was launched in October 2021, delivered to the RCN in September 2022, and commissioned on May 3, 2024.[126] The fourth AOPS, HMCS *William Hall*, was also commissioned not two weeks later, after being launched in November 2022 and transferred to the RCN in August 2023.[127] Still awaiting commissioning are the fifth AOPS, HMCS *Frédérick Rolette*, which was laid down in June 2022 and launched in December 2023, and the sixth and final of the RCN's Harry DeWolf–class vessels, the future HMCS *Robert Hampton Gray*, which was laid down in August 2023 and launched in December 2024, more than two months ahead of schedule.[128]

Though Irving has shown impressive progress in the construction of these vessels, this progress has not come without complications. The Harry DeWolf class has experienced problems with its diesel generators, communication system, freshwater generator, and fire suppression system. For instance, in August 2022, HMCS *Harry DeWolf* was forced to return to Halifax after setting course for an exercise in the Canadian Arctic, due to diesel generator difficulties that were then linked to the engine cooling system and identified to also affect HMCS *Margaret Brooke* and HMCS *Max Bernays*. HMCS *Max Bernays* has also experienced complications with its bow thruster, which allows the vessel to manoeuvre laterally and is thus instrumental in berthing and unberthing activities. However, such challenges are to be expected upon the introduction of a new class of warship. None are insurmountable, with HMCS *Harry DeWolf*, HMCS *Margaret Brooke*, and HMCS *Max Bernays* all returning to service in 2024 after remaining alongside in Halifax in 2023 for the necessary repairs.[129] Indeed, HMCS *Margaret Brooke* departed on January 12, 2024, for a six-week deployment to the Caribbean region with Operation *Caribbe*, playing a key role in Canada's participation in the multi-national counter-narcotics operation.

Once the final AOPS is completed, Irving will shift its focus and resources to the most complex and sizable element of the NSS: the construction of the Canadian Surface Combatants (CSCs)

[named River-class destroyers in June 2024] to replace, update, and combine the capabilities of the Halifax-class frigates and the already retired Iroquois-class destroyers. Irving and the Canadian government jointly issued a Request for Proposals, with a deadline of November 30, 2017. The Lockheed Martin Canada/BAE Systems Canada's Type 26 frigate design ultimately triumphed and was selected in the autumn of 2018 over its competitors, the F-100 Christopher Columbus–class frigate design submitted by a Spanish designer and a Dutch designer's De Zeven Provinciën–class frigate design. Together with Irving and the Canadian government, the Lockheed Martin Canada/BAE Systems Canada team has been working to customize the vessel's design to incorporate Canada's distinct needs. Preliminary details of the design were released in November 2020, the design review concluded at the end of 2022, and June 28, 2024, saw the commencement of construction on the production test module. The fleet of CSCs will consist of 15 vessels. With full-rate production scheduled to launch in 2025, the first vessel, HMCS *Fraser*, is anticipated to be delivered in the early 2030s, with the final ship expected by 2050.[130]

In addition to these large vessels, the Canadian fleet has also received new boats from the NSS's small boat construction element. In July 2015, the Canadian government announced the awarding of two contracts for the construction of the CCG's next generation of search-and-rescue lifeboats, to Ontario's Hike Metal Products and Quebec's Chantier Naval Forillon, with the first lifeboats being launched in 2017. Ontario's Kanter Marine Inc. also delivered in mid-2017 the last of its seven hydrographic survey vessels to the CCG, just over a year after it was awarded the contract.[131]

Thus, while the NSS is a decades-long process, and there is much work to still be done, there are clear signs of progress in the ongoing renewal of Canada's federal fleet. The RCN and CCG have benefitted – and will continue to benefit – from the billions of dollars in investments into revitalizing their fleets, bringing similar enhancements in capacity and capability to the nation's shipbuilding industry. Certainly, schedule delays have occurred, and these delays, in conjunction with inflation and technical and programmatic challenges, have contributed to rising costs for the NSS projects. These delays and increasing expenses have elicited ire from the Strategy's critics. However, these difficulties are not unique to Canada, and constructing advanced vessels and warships is inherently a complex and challenging task. Having a sustainable and dynamic shipbuilding and ship repair industry is key for Canada's economic prosperity, defence, and security as a maritime state, as is having a modern and capable fleet of naval and coast guard vessels. Fortunately, the National Shipbuilding Strategy has made – and will continue to make, if current plans are maintained – substantial progress towards both necessities.

Naval Procurement[132]

In Canada, the procurement of defence equipment entails a complex and lengthy process, involving the participation of numerous government departments. So complicated is this process that the Department of National Defence (DND) has a 265-page document outlining the guidelines for its internal process alone. For the Royal Canadian Navy (RCN), then, the process of procuring a new vessel is an extensive undertaking, replete with submissions, briefings, consultations, and approvals, with many opportunities for the extension or contraction of the projected project timelines. This is the case, too, for the vessels being procured under the National Shipbuilding Strategy (NSS). The risk and complexity associated with those projects, however, has tended to extend their timelines for completion, even as their basic procurement process remains fundamentally the same.

For the RCN, procurement projects proceed through a basic process comparable to that used by Canada's other military services.[133] The only exceptions are the projects undertaken under the NSS, namely the Arctic and Offshore Patrol Ships (AOPSs), Canadian Surface Combatants (CSCs), and Joint Support Ships (JSSs). For these projects, there are a handful of minute but key differences in the procurement process. While the RCN's equipment projects are comparable in process to those of the Canadian Armed Forces (CAF) or DND more generally, there is one principal distinguishing feature: the cost and scale of the projects. Specifically, while the RCN has relatively few procurement projects, it has a disproportionate proportion of the most expensive ones. Indeed, although the RCN has only 25, or 11%, of the total 234 defence procurement projects in Canada, these projects account for between 34% and 55% of the defence-wide total budget, with the Navy's project budgets ranging from approximately $70 billion to $80 billion. Though comparable in their overall procurement process, then, the RCN's projects are disproportionately expensive compared to DND's other procurement ventures.

In Canada, a defence procurement process encompasses five stages: Identification, Options Analysis, Definition, Implementation, and Close-Out. The Identification phase marks the inauguration of a procurement project, consisting of a DND or CAF project sponsor diagnosing or pinpointing a capability deficiency. On the heels of this initial identification, prospective sources of funding are determined, the strategic context for the possible project is defined, a project brief is compiled, and the High Level Mandatory Requirements are elucidated. A Project Complexity and Risk Assessment is subsequently performed, ranking the project on a four-point scale in which a four represents the riskiest and most sophisticated and difficult of projects. If the Defence Capability Board approves the proposal to remedy the capability deficiency, the proposal officially becomes a project.

A project's progression from the Identification stage to the Options Analysis phase recently necessitated an identified funding source, unless the project was characterized as a "Key" initiative. The 2017 Canadian defence policy, *Strong, Secure, Engaged*, identified the projects that then possessed funding and thus were eligible to transition to the Options Analysis phase. Moving forward, new projects seeking to make a similar transition – or projects in the Identification phase that have experienced cost increases since the release of *Strong, Secure, Engaged* – are required to complete and submit an Investment Plan Change Proposal to denote their source of funds under DND's investment plan before they will be able to shift into the Options Analysis phase.

In this Options Analysis stage, all projects with a budget in excess of $100 million (as well as some other projects) are required to have their High Level Mandatory Requirements subject to the review of the Independent Review Panel for Defence Acquisition (IRPDA). The project's Statement of Operational Requirement is thus formed, and alternatives for confronting the capability gap are delineated, which includes an analysis of the benefits and costs of the various options. If needed, policy coverage is ensured – sometimes requiring a Memorandum to Cabinet – and this phase can also include the first engagements with industry. A Business Case Analysis is conducted, the preferred option for addressing the gap is briefed for the Defence Capabilities Board's approval (towards the end of the Options Analysis phase), and the IRPDA conducts another review. A Senior Review Board receives a presentation on the project, and the Board is briefed annually thereafter regarding the project's progress. The Project Complexity and Risk Assessment first undertaken during the Identification phase is similarly updated. Moreover, an interdepartmental governance team comprised of representatives from Public Services and Procurement Canada (PSPC) – the department tasked with administering the procurement activity and negotiating the requisite contracts – undertakes a review of the project. From this point onwards, a vital component of the procurement process is the interdepartmental meetings that are coordinated by PSPC's Defence Procurement Strategy Secretariat, chaired by differing levels of senior executives, depending upon the cost of the project. In the case of the RCN's three procurement projects occurring under the auspices of the NSS, the National Shipbuilding Secretariat performs this secretariat function. Furthermore, any project with a budget in excess of $20 million is reviewed for the possible application of the Industrial Technological Benefits Policy. Those projects with budgets over $100 million are required to adhere to this policy, thus mandating the involvement of Innovation, Science and Economic Development Canada officials.

The conclusion of the Options Analysis phase sees the Program Management Board being briefed on the project, approving its transition to the Definition phase, and, for projects with aspects exceeding the $50-million budget threshold, recommending the Investment Management Review Committee's approval. Once the Program Management Board's approval is secured, details of the project and its specific plans are compiled into a Corporate Submission. The project receives expenditure authority on the basis of this submission, from, typically, the Treasury Board or the Minister of National Defence. The Minister of National Defence is authorized to approve a project only if its assessed risk and complexity – which, as previously mentioned, is evaluated on a four-point scale – falls within DND's ability to manage projects. Since DND's assessed capacity is currently a three, the Minister of National Defence is capable of approving projects for which the assessed risk and complexity is up to and including three. For the RCN's JSS, CSC, and AOPS projects under the NSS, their Definition phases entailed their receipt of conditional expenditure authority, requiring numerous Treasury Board approvals during that stage. However, many other projects receive a singular approval. Once a project has acquired this expenditure authority, contemplation shifts from analyzing how a capability deficiency should be addressed, to how the optimal option will be implemented, and the project moreover receives "Vote 5" Capital Funding. This is special financial authority that is utilized when the capital expenditures in question surpass $5 million, a portion of which is then allotted to the establishment of a dedicated DND project management office. This office assumes responsibility for the determination of substantive needs, schedule estimates, and cost projections. The Definition phase also sees the development and execution of the procurement strategy, including the release of tender documents and, if applicable, the consideration of bids.

The Implementation phase commences once the procurement strategy has been executed and the project has gained approval from the Program Management Board and, if necessary, the Investment Management Review Committee – the same bodies whose approval was required for the project to transition from the Options Analysis phase to the Definition stage. At the outset of the Implementation stage, PSPC acquires contracting approval from the Treasury Board in order to sign the contract for the procurement of the equipment. Once the equipment is delivered, the project attains an Initial Operational Capability, denoting the point at which the capability being supplied can be operationally utilized on a continuous basis. Full Operational Capability is the next milestone reached, which describes the stage at which all project deliverables have been completed and handed over. The project thus enters the Close-Out stage, the final of the five procurement stages in Canada. Progression into this stage indicates the official completion of all administrative project activities.

In all, a major DND project requires, on average, 16 years to progress through the five stages of procurement. Projects of greater risk and complexity tend to require extended timelines. There are a variety of other factors that can increase or decrease the time required for a project to proceed from Identification to Close-Out, including the project's budget, political decisions, and the extent to which interdepartmental actors are aligned when approvals or decisions are required. For the RCN, its three NSS projects are among DND's most complex and risky. As such, the AOPS, CSC, and JSS projects have encountered all the aforementioned factors, in addition to the further complication of being a component of a national strategy seeking to restore and enliven the shipbuilding industry in Canada. As such, the shipbuilding projects planned and progressing under the NSS can be anticipated to take longer than the RCN's other projects to move through their Identification, Options Analysis, Definition, Implementation, and Close-Out stages.[134]

The Stages of Warship Procurement

The procurement process for defence equipment, and especially for naval equipment, is a tremendously complex, complicated, and prolonged undertaking. In recent decades, the bureaucracy surrounding the process has only increased, in part due to the substantial sums of money involved. The Government of Canada has, for several years, spoke of simplifying and streamlining the procurement process, with the Liberal government of Prime Minister Justin Trudeau proposing (in 2019) to concentrate it within one office called Defence Procurement Canada. This centralization was never achieved. Instead, the procurement process continues to follow the 2014 Defence Procurement Strategy. The Independent Review Panel for Defence Acquisition (IRPDA), created in 2015, is also involved, offering independent advice and overseeing major projects with values in excess of $100 million. In 2018, the government also introduced the "Defence Investment Plan" to further augment existing strategy[135] by streamlining the costing, approval, and project governance processes of smaller and less complex projects. Still, defence procurement remains an onerous and formidable process, partly due to the sheer number of actors involved in its many stages.

Under the National Shipbuilding Strategy (NSS), the process for maritime procurement involves four central federal departments: the Department of National Defence (DND), Public Services and Procurement Canada (PSPC), the Department of Fisheries and Oceans (DFO)/Canadian Coast Guard (CCG), and Innovation, Science and Economic Development (ISED). Each department has differing responsibilities with respect to major naval or maritime procurement projects. DND and the CCG are tasked with defining requirements, developing specifications, and analyzing options and their cost estimates. Securing funding and policy approval is also within their purviews, as is providing technical expertise and managing the integration of services and equipment during the procurement or project. Meanwhile, PSPC is responsible for leading the industry and stakeholder engagement prior to and during the process, developing the procurement strategy, spearheading the solicitation process, overseeing the price and technical benefits evaluations, and managing the consequent performance of the contract, vendor, and procurement. Finally, ISED assumes responsibility for administering the Industrial and Technological Benefits (ITB) Policy, offering recommendations on the policy's application to the procurement project, and determining – with aid from Global Affairs Canada – the evaluation criteria to capitalize on the economic benefits from the contracts and export elements of that criteria.[136]

The procurement process for the Canadian Surface Combatant (CSC) provides a case study to briefly examine the complexity of the defence procurement process, from the Identification and Options Analysis phases through to the Definition, Implementation, and, finally, Close-Out stages.[137] The first stage of the procurement process is the Identification stage. Here, the Royal Canadian Navy (RCN) identifies a capability gap. The RCN brings this capability gap to DND for it to act as the project's sponsor and advocate to the government for funding.

After approval for the project is given, the Options Analysis stage involves evaluating and ultimately determining how to procure what the RCN needs. Discussion ensues about the type of design that would best fulfill the Navy's requirements (e.g., a frigate, coastal defence vessel, destroyer, etc.), the number of vessels that would be needed, and whether the vessel(s) would be constructed in Canada (and, if so, where) or purchased off-the-shelf internationally.[138]

Different actors, in these discussions, can have different motives and objectives. For instance, while the RCN may emphasize the capabilities of the vessel and timeliness of its procurement, the Treasury Board may prioritize the project's budget, and the Canadian government may stress economic benefits, the creation of jobs, and industrial strategies. Cost, understandably, is a key consideration during this phase, with evaluations being made on the project's cost parameters, as well as the funding the government is willing to allot to the project. A further cost consideration in this Options Analysis stage is how the cost of the naval project measures against the costs of comparable builds elsewhere, which can be complicated comparisons to make given that different countries include different components in their costings. Once these factors have been considered and decided upon, and the project's general parameters have been outlined in a Statement of Requirements document, the government then disseminates a Request for Proposals, specifying the build's conditions, noting the parameters for funding, and requesting the submission of proposals. Parties interested in undertaking the procurement project thus submit their designs, which are subsequently analyzed and evaluated with a points-based scoring process that examines the industrial, financial, and technical elements and benefits of the proposals. The government thereby selects a design, called the Total Ship Reference Point (TSRP). For the CSC project, the Government of Canada received bids from three companies and ultimately selected BAE's Type 26 frigate design proposal as its base design, awarding the contract in 2019.[139]

The Options Analysis stage follows the Definition stage. Here, designers make alterations to designs to accommodate specific national regulations and requirements – for instance, regarding weapon systems, pollution control, or crew accommodations – or operational needs. For the RCN, this process is called the "Canadianization" of vessels. To Canadianize the CSC, the "parent design," or the initial design providing the framework and foundation of the eventual vessel, was examined and tweaked to produce what is essentially a design which, while largely similar to the Type 26, has diverged in many important respects.[140] The Definition stage seeks to determine the differences the vessel will have. Here, engineers at the selected shipyard – in the CSC's case, Irving Shipbuilding – and RCN project managers assess and evaluate the project design. The ship design, supplier engagement, and production engineering pursuits undertaken to prepare for a vessel's construction are all included in the Definition contract work.

Together, the shipyard and RCN project managers produce a second ship design, offering a more detailed and fleshed-out level of design, followed by simulations of the vessel's build. This stage also involves efforts to firm up the supply chains and acquire long-lead items that must be purchased before construction commences, so that all required materials are available when and as needed. The production processes are established and confirmed, and a test module is created prior to the vessel's construction. A critical element to determine in this stage is the size of the vessel, which both impacts and is impacted by the roles the ship will be expected to fulfill and how it will fulfill them. While increasing a vessel's size, for instance, may increase its capabilities, it will also increase its power generation requirements. A further consideration in this stage is the weapons that will be included, with consideration given to their weight, power requirements, and placement, in addition to the degree to which they will be interoperable with allied vessels' capabilities. Weapon control, communication, fire suppression, and various other computer systems also must be decided upon and integrated into the design, allowing for, in this phase, the adjustment and tweaking of cash flow projections, cost estimates, and production engineering

documentation as the vessel nears construction. It is these questions and considerations with which the CSC project is currently grappling.

Once the vessel and its structure are defined, the project transitions into its Implementation stage, marking the commencement of its actual construction. The major decisions about the vessel have been made. The shipyard has established the requisite supply chains and ordered the electronics, weapon systems, long-lead-time materials, etc. In the CSC's case, this Implementation stage will proceed in sections, with specific delivery schedules for the initial three ships and their required shore infrastructure, followed by further groups of ships, each with their own contracts. As the project is completed, it enters its Close-out stage, which is the point at which the final vessel has been constructed, has completed its builder's trials and RCN acceptance trials, and has been delivered to the Navy. At this point, final bills and tallies can be completed, and the process is effectively complete. Given the complexity of shipbuilding and naval procurement projects, this stage often occurs years following the Navy's initial documentation of a capability gap.

This overview is a simplification of a far more extensive and intricate process. At each stage, various government departments offer input into budgets, industrial and regional benefits, and risk assessments, with discussions also simultaneously occurring with and between industry. For the CSC, each stage has entailed the negotiation and signing of contracts between the Government of Canada and Irving Shipbuilding to confirm that the funding required to support the project is available. Irving itself negotiated contracts with Lockheed Martin and other suppliers. Any defence procurement process is thus a lengthy and time-consuming undertaking, with warships being particularly slow to procure given their size, complexity, and infrequency of construction in Canada. As Canadian shipyards rebuild capacity and hire the personnel needed to perform such massive procurement undertakings, and as the government rebuilds the expertise of its procurement personnel, it is hoped that each individual project will require less time and be less expensive. It is also hoped that new shipbuilding procurement projects will enable naval equipment manufacturers in Canada to continue to employ Canadians and produce equipment. Indeed, these were broad aims of the National Shipbuilding Strategy as a whole – creating a long-term naval procurement plan to replace the boom-bust cycle of Canadian shipbuilding with a more continuous and regular procurement capability.

The Modernization of Naval Ships

The regular maintenance of vessels is not the only requirement for a navy seeking to maintain an effective and efficient fleet. Indeed, a navy must also undertake naval modernization, defined as the process by which a navy upgrades its operational capabilities to ensure it can perform its government-assigned functions and/or in response to an emerging or existing threat.

Modernization also necessarily occurs when a system used on a vessel becomes technologically obsolete or unsupportable – for instance, when the requisite replacement parts become obsolete and can no longer be acquired, or when the software used in the weapon, communication, or navigation systems ages and no longer meets requirements. Changing environmental standards and personnel compositions (for instance, the integration of more women into the Royal Canadian Navy (RCN)) also require that vessels be modernized to ensure they conform to new safety, accommodation, and technical standards. Cost considerations could also compel modernization, if a system is still operational but requires parts that have become too expensive to acquire. As a result, a vessel will typically need significant hardware, firmware, and software changes to continue to operate effectively, as such systems do not generally last for the entirety of a vessel's lifespan (particularly when warships are often used for many years). Since these changes involve the integration into the existing vessel of new elements, systems, or equipment, rather than fixing the preexisting systems, this is called modernization instead of maintenance. Modernization typically is a more time-intensive – and expensive – process than maintenance. Generally, modernization includes any significant changes, especially if those changes add a new capability.

There are two types of naval modernization. While ship modernization entails retrofitting an existing platform, fleet modernization consists of procuring an entirely new vessel. The modernization process commences with an assessment of the RCN's capacity to perform its requisite missions. The Directorate of Naval Requirements (DNR), with the aid of intelligence reports, information from allies, and engineering advice, compiles a Statement of Operational Capability Deficiency (SOCD), which in turn sparks a variety of processes. The Naval Engineering Test Establishment (NETE), the primary naval evaluation and test centre of the Department of National Defence (DND), could become involved to ensure that the engineered equipment is safe and effective.[141] The process could also include Defence Research and Development Canada (DRDC), in the event that new capabilities are being tested or developed. The Director General Maritime Equipment Program Management (DGMEPM) would be involved from an engineering standpoint in identifying the requirements of the modernization program, and the RCN could also draw upon and involve the Canadian Forces Maritime Warfare Centre, as well as other operational information/reports and intelligence from DND or from allies. Today, the RCN and/or Assistant Deputy Minister (Materiel) (ADM Mat) also depend on industry to determine the means by which requirement deficiencies can be addressed at the ship system or operational level. Following the determination of the operational requirements, ADM Mat (DGMEPM) assumes responsibility for overseeing the modernization program and ensuring its compliance with the RCN's needs. In the ensuing procurement process, ADM Mat works alongside Public Services and Procurement Canada (PSPC), which is the contracting authority for the Government of Canada that assures that contractual commitments are fulfilled. The modernization process ends with the system or vessel's acquisition, installation, set-to-work, and RCN acceptance trials.

Navies often perform "mid-life" modernizations of the vessels in their fleets. An example is the RCN's Halifax-class frigates. By the mid-2000s, these vessels had exceeded a decade in service. As such, the Government of Canada commenced a refit program – the Halifax-Class Modernization/Frigate Life Extension (HCM/FELEX) – to modernize the vessels. The government awarded contracts for the program in November 2008, with a budget of $4.3 billion.[142] Under the program, the vessels received new equipment and new capabilities, including a new Combat Management System (CMS-330) involving the computers controlling their sensors and weapons, new air surveillance radars, altered crew accommodations, better damage control systems, new fire control systems, Integrated Platform Management (including engine room monitoring), and updated navigation, communication, and electronic warfare systems. Seven vessels were modernized on the East Coast and five on the West Coast, with HMCS *Regina* (the final frigate to be modernized on the West Coast) being returned to the RCN in April 2016, and HMCS *Toronto* (the final frigate to be modernized on the East Coast) being finalized in November 2016. January 2019 marked the formal and official closure of the program. Such complex and extensive modifications like those performed under HCM/FELEX, which require overhauls of several systems within a vessel's hull, are undertaken by the contracted shipbuilder in a dry dock. Typically, these mid-life modernizations occur before the construction of a new platform that is able to meet both the current requirements as well as the anticipated requirements that the preexisting class cannot. In the case of the Halifax class, these modernizations are intended to keep the vessels functional and operational until their successors, the Canadian Surface Combatants (CSCs), are constructed and enter into service.

The RCN's Victoria class of submarines provide another case study of the naval modernization process in Canada. Since their purchase in 1998, all four of the submarines have undergone extended docking work periods (EDWPs). For instance, HMCS *Corner Brook* endured an EDWP from 2015 to 2018, which repaired damage the vessel had incurred in 2011 (including replacing its sonar bow dome and sections of its external structure) and installed upgrades to the torpedo combat system, primary sonar system, communications intercept capabilities, and satellite communication system.[143] The modernization of the Victoria class will continue in the coming years under the Victoria Class Modernization Program.

Overall, how a modernization program proceeds is contingent on whether the project is part of a package of installations, whether it is a one-off, or whether it is a combination of both. Modernization work must be prescheduled, with its scheduling depending on the anticipated time needed for the refit and major docking periods, as well as the program's impact on or place within the other docking or refit work occurring at the shipyard. The scheduling must also account for the need to maintain the readiness and capability of the overall fleet.

Scheduling complications are not the only challenges that arise from modernization programs. Indeed, integrating new equipment and systems into an older vessel, to function alongside older equipment and systems, can create interface issues. However, given that warships tend to remain in service for lengthy periods of time, and because weapon and communication technologies evolve and change rapidly, modernization is a necessity for warships and naval vessels to remain operational, effective, and efficient throughout their years of service.

Maintaining the Naval Fleet

Sustaining the fleet of the Royal Canadian Navy (RCN), as well as its status as a blue-water navy capable of deploying across oceans in service of Canadian objectives internationally, requires close attention to the maintenance of its vessels. When such global operations expose the RCN's fleet to temperature extremes, varying from the Arctic cold to the heat of the Caribbean, the equipment deployed for such operations is subject to considerable wear and tear. Even exposure to salt water and air while docked can impact a vessel's electrical and mechanical equipment, on top of the wear sustained during travel.

Consequently, a regimented and regular system of maintenance is essential for naval vessels to remain in adequate condition to deploy and fulfill their operational mandates. Since a vessel's capacity to successfully undertake a mission is contingent on both the training of its personnel and the readiness of its equipment, fleet maintenance is integral for ensuring this continual operational readiness. Adequately maintained equipment and machinery typically have a lower likelihood of failing during a deployment, and as such, the RCN ensures that the equipment and machinery aboard its vessels is completely operational prior to any departure or deployment. This maintenance is also imperative for crew safety, in its capacity to minimize the risk of machinery breaking and mitigate the possibility of flooding, fires, spills of hazardous materials, or the vessel sinking. Maintenance is furthermore critical for the sustainment of the RCN's fleets, given Canada's proclivity to operate warships for extensive periods of service. From its hull to its weapon system, from its propulsion system to its navigation and communication technologies, all elements of a warship require regular maintenance and check-ups to ensure that the vessels can operate for the decades-long lifespans required of them. Of course, as vessels age, maintaining them becomes more complex and intensive – and expensive.

Maintenance activities fall under two categories. While corrective maintenance seeks to repair a component or element that has broken, preventive maintenance aims to ensure that those components or elements do not break in the first place. This preventive maintenance is a priority for the Navy, which engages in routine inspections and maintenance of all vessel equipment to ensure that no element fails and to prolong the vessel's lifespan as much as possible. The Navy may premise the frequency of these routine inspections and maintenance either on time (e.g., the number of hours a diesel generator has functioned) or the equipment's condition (e.g., the number of rounds that a gun has fired).

There are, moreover, three lines or levels of maintenance workers. At the forefront is the vessel's crew, which conducts minor repairs and routine service. Submarines and warships carry technicians in their crews to perform necessary repairs to keep equipment operational, using spare parts on the ship that are restocked at its home port prior to any exercise or mission.[144] The second maintenance line is the Fleet Maintenance Facility (FMF). With two located in Canada – FMF Cape Breton in Victoria and FMF Cape Scott in Halifax – the FMFs can conduct most repair and maintenance duties while vessels are alongside. They boast specialized shops (for instance, propulsion, radar, sonar, electrical, communication, etc.) and trained workers to contend with more complex equipment and systems. Personnel at the facilities also have access to the Naval Supply System, a sizeable warehouse located in the dockyard that contains spares for all RCN-used equipment. The third and final line of maintenance is the original equipment manufacturer (OEM).

The RCN maintains maintenance contracts with the manufacturers of the complex equipment utilized in vessels, and thus this line of maintenance is reserved for issues and systems that neither the vessel's crew nor the FMFs are qualified to address.

Such maintenance duties can remove a vessel from service for lengthy periods of time, depending upon the scope and complexity of the maintenance being conducted. Time frames range from short work periods (SWPs) of between one and three weeks, to long/extended work periods (EWPs) of weeks to months, to extended docking work periods (EDWPs), which can last for several years. Unless a mission-specific fitting is required or an urgent repair must be conducted, vessels undergo their work periods in turn. When a vessel enters its maintenance period depends in part on the location of the maintenance, since maintenance on a vessel must be prebooked and prescheduled to ensure the requisite parts and workshop are available. It also is contingent on the operational schedule of the Navy. For instance, the RCN demands that a minimum of eight of its 12 frigates can deploy at any given time, and thus maintenance schedules consider the need to ensure that adequate numbers of vessels are available for any commitment that could arise.

The RCN's 12 Halifax-class frigates provide an apt case study of these maintenance duties. Divided between the Atlantic and Pacific Coasts, these frigates are the RCN's backbone. They are also aging. The first frigate of the class, HMCS *Halifax*, entered service in 1992 – over three decades ago. The other frigates entered service between 1992 and 1996, making even the youngest vessel just shy of 30 years old. Moreover, there are no plans for the frigates' immediate replacement: the Government of Canada announced in July 2019 its plan to keep the Halifax class in service until the early years of the 2040s through the investment of over $7.5 billion, at which time the Canadian Surface Combatants are planned to enter into service.[145] This plan means a significantly extended lifespan for the Halifax class, as HMCS *Halifax* will be nearly five decades old in 2040. The need, then, for these frigates to remain operationally ready and effective for an approximate two decades to come means that docking maintenance work periods are crucial to maintaining the class's reliability and availability – and thus the RCN's capabilities – until it is replaced by the River-class destroyer, beginning in the early 2030s. To divide the requisite maintenance work between various shipyards, the Government of Canada has awarded contracts to Irving Shipbuilding, Seaspan Shipyards, and Chantier Davie, with work on the frigates having commenced in the early 2020s.

A similarly appropriate case study is the RCN's Victoria-class submarines. Purchased from the United Kingdom in 1998, and operational after several years of "Canadianization,"[146] the Government of Canada now aims for the four submarines of the Victoria class to remain "operationally effective" into the mid-2030s.[147] As such, and given the complexity of the submarines and their operation in extreme environments, the Victoria-class submarines are subject to routine maintenance based on a rotating schedule.

The government's Victoria In-Service Support Contract, entered into with Canadian industry to maintain and support the class through 2023 (and potentially beyond, if the contract is extended),[148] provides for any requisite engineering services, overhaul and repair, material acquisition, and organization of the maintenance and refit schedule.[149] Generally, then, the plan is to operate the submarines in a cycle, according to which each submarine is available for a six-year operational period and then undergoes a two-year period of extensive maintenance. Docking work periods are to be rotated between the submarines to ensure that, at any given point, the RCN has

access to three completely operational submarines, while the fourth undergoes maintenance. This plan has not always been successful. For instance, after a year of intense activity in 2018, which saw the submarines travelling across the Atlantic and to Asia for various taskings, all four submarines were in maintenance in 2019, and not one deployed to sea. Several of the Victoria class were able to return to sea in 2020.

In general, the maintenance and readiness of a vessel's equipment is a key determinant of its capacity to be effective and efficient from an operational standpoint. Given the exorbitant expense of procuring naval vessels, governments are prone to attempting to expand their lifespans and keep vessels in service for as long as possible. While the effectiveness of this can be debated, in light of the escalating maintenance costs as vessels age and the possibility of equipment becoming obsolete, it is clear that sufficient maintenance of the RCN's vessels is crucial to ensuring their continuing capabilities and capacity to protect, defend, and serve Canada.

Logistics and Support

It has been said that "an army marches on its stomach." Though variously attributed to both Frederick the Great and Napoleon, its meaning is less ambiguous: military forces must have adequate supplies and provisions to operate.[150] Military planners are cognizant of this necessity, framing it in military discourse as the "tooth-to-tail" or "teeth-to-tail" ratio, reflecting the ratio of the personnel engaging in combat (the teeth) to those providing the supporting logistics and supply services, such as ordnance, signals, logistics, food, water, fuel, spares, clothing, and medical services (the tail). Oftentimes, the tail of a military force is larger than its teeth and just as important – despite the public's tendency to accord it less recognition. Though the concept of the ratio has differing definitions and is hotly contested, history has shown that a force's lack of access to sufficient supplies is disastrous for both the mission and the personnel involved, and that a military force is much more than just the personnel holding or operating weaponry.[151]

Understanding the meaning of logistics is integral for this discussion. Strictly speaking, logistics is "the science of the movement, supplying and maintenance of military forces in the field." The *Random House Dictionary* defines it similarly, as "the branch of military science dealing with the procurement, maintenance and movement of equipment, supplies and personnel." Even for a smaller military like Canada's, this task is complex and challenging. It is no easy feat to maintain an understanding of what a military requires and ensure that a specific force receives what it needs when it is needed. Nor is it simple to maintain, manage, and move the military's resources, while simultaneously monitoring the financial element of those resources.

On the macro level, the Canadian Armed Forces (CAF) as a whole possesses a complex system of logistics and support. For instance, the military keeps multiple warehouses in which it stores supplies ranging from boots to spare equipment parts, and keeping track of these supplies and resources is an intensive process involving the accumulation and processing of significant amounts of information from each of the CAF's three services. For the Royal Canadian Navy (RCN) itself, the logistics and support system entails keeping track of which vessels are being deployed, the maintenance that different vessels require, the parts that are needed and when they are needed, the personnel that are required and available for specific vessels and at what times, budgetary concerns, as well as a host of other considerations. Ships being deployed require records of the various supplies they will need, in addition to the maintenance that is being conducted and that will be required, potentially involving the ordering of parts and scheduling of repairs upon its return to port.

This is a tremendous quantity of information, and the CAF has developed systems to manage it. Computer-based management programs have proven adept at handling and keeping track of these waves of information, once the data is gathered and entered.[152] The predominant management program utilized in the CAF and thus the RCN is the Defence Resource Management Information System (DRMIS). Introduced by the Department of National Defence (DND) in 2010, DRMIS was itself an amalgamation of the Financial Management Accounting System (FMAS) – a financial management system – and the Materiel Acquisition and Support Information System (MASIS) – an equipment management system.[153] At the time of its creation, DRMIS was predominantly a financial and technical system. Since then, however, supply chain information and other business processes (such as those regarding real property management) have been

integrated into the DRMIS system. This has effectively consolidated the processes within a singular program,[154] which is now the source of support and information for essentially all elements of the defence financial and resource process throughout the CAF chain. It enables all personnel with a role in the life of an asset to work in the system in almost real time. For instance, a component problem requiring a replacement part can be documented in the system, the person tasked with buying parts can view the need for an order and place an order accordingly, the technicians can produce a work order, and, when the part arrives and the maintenance is performed, the work can be documented in the system, thus finalizing the full paper trail for any auditors or budgeters.[155] The DRMIS system is even accessible to vessels in active deployments.[156] While at sea, information inputted into the system can update naval repair facilities about the ship's status and keep them apprised of any problems that require attention upon its return to its home port. By allowing repairs to be planned (including the negotiation of any required contracts with the private sector) and equipment and some supplies to be ordered in advance, prior to the vessel's return, the DRMIS system enables repairs to be scheduled more effectively. This, in turn, potentially saves the Navy time and money.

The creation of such a computer system to maintain information on all components of the RCN's maintenance, costs, and support has been exceptionally valuable. However, it does have some restrictions or setbacks. The system's security is a continuous concern, like with any computer-based program or system. The quality of the information it generates or provides is contingent on the information entered into it, and its efficacy is inevitably compromised if the information it contains is inaccurate or outdated. Though it tracks maintenance and support needs and can order the required material, it does not eliminate the need for the personnel and capability to actually perform the work, and it does not reduce the need for support or supply vessels to keep warships operational and well stocked during their deployment. Moreover, while the system has certainly simplified elements of the logistics and support process, its requirement of multiple rounds of forms (due to concerns that the system could be abused) and lack of user-friendliness can make fulfilling simple requests excessively challenging and onerous.

This macro system is only a fragment of the overall image of the CAF's logistics and support system. Indeed, aboard each individual RCN vessel, there is a micro logistics, supply, and support system keeping the vessel and its personnel supplied. Each vessel has a Logistics Department, led by a logistics officer, which is tasked with a variety of responsibilities, including the acquisition, storage, and accounting for all test equipment, tools, spare parts, provisions, and clothing. This department varies in size depending upon the vessel's class, but it generally encompasses four sections, which are individually responsible for the galley (kitchen) operations, stores/supply, finance, and wardroom operations. Each of these four sections typically comprise between five and seven personnel, with each section head reporting to the logistics officer. The logistics officer also serves as the vessel's finance officer, bearing responsibility for, for instance, paying invoices and bills.

The Logistics Department of a vessel is a crucial component of ensuring its smooth, effective, and efficient operation, providing the parts, food, materials, and finances needed for all personnel aboard. For instance, the senior cook aboard a vessel manages the acquisition, storage, and preparation of all food that is served on the vessel,[157] including accounting for and ordering the supplies required for the rations, galley operations, and cafeteria service. Under the command of

this senior cook, the vessel's stewards and cooks work in shifts to ensure round-the-clock food services, potentially preparing up to four complete meals each day to ensure that personnel receive adequate nutrition regardless of their watch rotation. These stewards, cooks, and Logistics Department personnel moreover provide onboard operations support in the damage control section bases, as Casualty Clearing Team members, and through their involvement in the Chemical, Biological and Radiological Monitoring and Decontamination Teams.

In addition to their day-to-day responsibilities, personnel of the Logistics Department are also tasked with fulfilling more occasional and specific support needs. For instance, the department organizes and undertakes any reception or official function a vessel holds in pursuit of naval diplomacy. It arranges the procurement and transport of any spare part that must be shipped to the vessel from Canada, including handling all paperwork required to ensure the part's progression through customs. It also organizes commercial air transport for any crew member departing from or joining the vessel during its deployment. The department furthermore arranges and finances fuelling and garbage collection at foreign ports. The Logistics Department arranges several morale-boosting activities, too, such as coordinating Christmas dinners for deployed crews.

The CAF and RCN thus have a well-established system in place, from the macro level of the forces as a whole to the micro level of the individual vessel, to ensure that all logistic, supply, and support needs are adequately met. This system will continue to evolve as military support becomes increasingly privatized. Following the culmination of the Cold War, Western governments cut military spending in the hopes of attaining a "peace dividend." As a result, the private sector assumed some of the military's former support roles and functions, due to the belief that the private sector could perform those tasks more inexpensively and efficiently. From training to equipment maintenance, from security to meal preparation, private companies have assumed the responsibility for numerous military support programs. Despite controversy regarding whether this has indeed saved money or was a "good" idea, it is likely that the military's support "tail" will continue to become increasingly the responsibility of the private sector. For instance, as the military integrates progressively more advanced technological equipment – like autonomous and uncrewed vessels – into its range of assets, the companies that produce that equipment will be responsible for their maintenance, their operation, and training personnel in their use. It is yet unclear what new complications and challenges may arise from this increasing incorporation and integration of private-sector industries into military logistic, supply, and support systems.

Thus, while the combat components of modern military forces often receive the most public recognition, attention, and acclaim, their successful operations are contingent on the extensive "tail" of logistics, supply, and support that aid them. For the RCN specifically, the impending construction of the Joint Support Ships (JSSs) under the National Shipbuilding Strategy will facilitate naval logistics and supply, enhancing the Navy's ability to deliver critical food, water, fuel, and spare parts to vessels operating internationally. These JSSs will join the complex and primarily effective logistics, supply, and support system of the CAF and RCN.

The River-Class Destroyers

The River-class destroyers are the planned replacement for Canada's now-retired Iroquois-class air-defence destroyers and the current fleet of Halifax-class frigates. For most of their development life, the future destroyers have been known as the more generic Canadian Surface Combatants (CSCs), only being given their current class name in June 2024. The River class is the most complex and expensive element of Canada's National Shipbuilding Strategy (NSS), and the Royal Canadian Navy intends to procure 15 of the vessels.

The CSC program was a central component of the NSS, and, in January 2015, the government named Irving Shipbuilding the prime contractor for the program, with the ships to be built in Irving's Halifax Shipyards. In 2017, bids from several international firms were received for the construction of the CSC. The final contenders consisted of a Lockheed Martin–led consortium, which put forward a design based on the British Type 26 frigate (Global Combat Ship) by BAE Systems; Alion Science and Technology, which proposed a CSC based on the Dutch De Zeven Provinciën air-defence and command frigate; and a Navantia/Saab/CEA Technologies consortium, which offered a design based on the Spanish Navy's F-105 frigate.

In October 2018, it was announced that the BAE–Lockheed Martin group was selected as the "preferred" bidder in the CSC program. The BAE–Lockheed Martin (LM) team then entered the "due diligence process," which included negotiations with BAE-LM on intellectual property rights, an assessment of the proposed combat systems, an assessment of BAE-LM's financial capability to deliver the project, and other administrative matters.

In February 2019, the government confirmed that the bid from Lockheed Martin Canada had been selected for the design for the CSCs. Irving Shipbuilding, the project's prime contractor, awarded a sub-contract to Lockheed Martin Canada for work to finalize the design. While the CSCs will be based on the British design, they will be tailored to Canadian requirements, a process that will ultimately produce a uniquely Canadian ship.

The Type 26 was originally ordered by the United Kingdom's (UK) Ministry of Defence as a replacement for the Royal Navy's aging Type 23 frigates. It was designed as a multi-mission warship, able to undertake anti-submarine warfare, air defence, and general-purpose operations. The first contract for construction of the ship was awarded by the British government in July 2017, and, by winter 2018, three ships had been ordered.

In June 2018, the Australian government also announced that it had selected a modified version of the Type 26 platform as the replacement for its Anzac-class frigates. The Royal Australian Navy will procure these vessels as the Hunter class, with construction by BAE Systems Australia in Osborne, South Australia.[158]

The new Canadian ships will also be modified versions of the Type 26 design, though reclassified as guided missile, helicopter-capable destroyers (North Atlantic Treaty Organization (NATO) designation DDGH). There is also a mission shift from the British base design. While the Royal Navy's Type 26 is focused on anti-submarine warfare (ASW), the River class includes extensive modifications to enhance air defence capabilities. Weighing around 8,000 tonnes, they are closer

in size to Second World War–era light cruisers. The first batch will include HMCS *Fraser*, HMCS *Saint-Laurent*, and HMCS *Mackenzie*. Additionally, the land-based test facility will be named HMCS *Assiniboine*.[159]

Specific weapon systems and design characteristics continue to be finalized, but the Department of National Defence issued a document in November 2020 that illustrates that the Navy has begun to solidify the capabilities of the ships.[160] They will possess an area air defence capability, which was lost to the RCN with the retirement of the Iroquois-class destroyer. This includes the RIM-116 Rolling Airframe Missile (RAM) and others housed in Mk 41 cells. The primary missile armament will include Raytheon SM-2 Block IIIC medium-range air defence missiles and Evolved Sea Sparrow Missiles (ESSMs) Block II, alongside the Kongsberg Naval Strike Missile.[161]

The ships will house an anti-submarine warfare capability built around advanced towed array sonar and ship- and helicopter-launched torpedoes – as well as defensive weapons capable of countering these capabilities in others. Finally, ships will also be armed with the Leonardo 127-mm Oto Melara Vulcano gun, chosen for its lighter weight and advanced ammunition options. Instead of the Phalanx CIWS, the River class will feature two Leonardo Lionfish 30/X 30-mm stabilized rapid-fire guns, offering increased range and firepower.[162] The CSCs will have sophisticated command and control suites, electronic warfare and surveillance/communication capabilities, and a modern combat management system.

The ship will be powered by a combined diesel-electric or gas (CODLOG) propulsion system, and its acoustically quiet hull is an essential feature for the kind of anti-submarine warfare on which the RCN has focused since the Second World War. The CSCs will possess an expanded flight deck capable of landing the CH-148 Cyclone helicopter and aircraft similar in size to the Chinook.

Delivery of the first River-class destroyer, HMCS *Fraser*, is expected in the early 2030s, with the final ship expected by 2050.

II. The Fleet

The Halifax-Class Frigates

The Royal Canadian Navy's (RCN) Halifax-class frigates are the backbone of the fleet's combat capability. Based in Halifax and Esquimalt, the RCN's 12 frigates regularly deploy around the world, either independently or with North Atlantic Treaty Organization (NATO) or other allied countries. They are versatile ships, and their missions can vary considerably from fisheries patrols and surveillance to combat operations.

The ships were designed in the 1980s for anti-submarine and anti-surface warfare as a replacement for the aging vessels of the St. Laurent, Restigouche, Mackenzie, and Annapolis classes. They were constructed by Saint John Shipbuilding in Saint John, New Brunswick, and by MIL-Davie Shipbuilding in Lauzon, Quebec, between 1992 and 1997 in two batches, ordered in 1983 and 1987. The frigates are large (for Canada), at 134 metres in length. Despite their size, the ships are manoeuvrable and flexible. They have a top speed of over 30 knots and can come to a full stop from that speed within one ship length.

Halifax-class ships:

- HMCS *Halifax* (330)
- HMCS *Vancouver* (331)
- HMCS *Ville de Québec* (332)
- HMCS *Toronto* (333)
- HMCS *Regina* (334)
- HMCS *Calgary* (335)
- HMCS *Montréal* (336)
- HMCS *Fredericton* (337)
- HMCS *Winnipeg* (338)
- HMCS *Charlottetown* (339)
- HMCS *St John's* (340)
- HMCS *Ottawa* (341)

As noted, the frigates were originally planned for anti-submarine warfare (ASW), a role Canada played very well during the Cold War. Their ASW capabilities and effective operating range are augmented by the addition of a maritime helicopter on the flight deck at the back of the ship. Until recently, the ships carried the CH-124 Sea King helicopter, but the Sea Kings have been retired after more than 50 years of service. The ships are now equipped with the CH-148 Cyclone.

Having the capability to operate helicopters is a major asset for the frigates. They extend the range and roles of the ships. But using helicopters from ships adds a complexity to frigate operations. To operate these helicopters in open ocean conditions, a Canadian-designed Recovery Assist, Secure and Traverse system (RAST) – known as the "bear trap" system – is built into the deck, which facilitates the launch and recovery of helicopters even in rough seas.

The ships faced the awkward problem of being designed for the Cold War but entering service after the Cold War had ended. With the demise of the Soviet Union in 1991, the RCN faced the old challenges, as well as a set of new challenges. For years after the Cold War ended, it seemed that traditional state-based conflicts were a thing of the past. However, following the Russian invasion of Ukraine in February 2022 and aggressive Chinese actions in the Pacific, state-based conflict on land and at sea is again on the agenda. In addition to the old challenges, Canadian warships now increasingly must deal with threats that are not state based or combat related – what are referred to as unconventional threats – in coastal or littoral areas. Naval ships must deal with threats such as explosive-laden speedboats and short-range, land-based anti-shipping missiles. As well, naval ships rely more and more heavily on technology, and that raises the possibility of cyberattacks on communication, navigation, and/or weapon systems – a threat that must be taken

seriously and addressed with countermeasures. Innovations in procedures and tactics have enabled the frigates to operate more effectively in the new threat environment. In conjunction with Canada's allies, the frigates are now practising defensive operations with specially designed drone targets and Canadian-designed uncrewed speedboats.

The Halifax-class frigates protect themselves through a layered defence, which incorporates Sea Sparrow missiles, 57-mm guns, Phalanx systems, and RAMSES electronic countermeasures systems. The frigates' surface-to-surface missile is the Harpoon Block 1C. Two quadruple-launch tubes carry eight missiles, which can deliver a 227-kilogram warhead up to 130 kilometres. These weapons can be used by the ship to attack enemy vessels or targets ashore. For air defence, the ships employ the Sea Sparrow missile. The Sea Sparrows are designed to intercept incoming missiles, drones, or aircraft up to 50 kilometres out from the ship and can deliver a 39-kilogram (86-pound) warhead at speed Mach 1.6. These weapons can be used against enemy aircraft or incoming missiles. If this defence fails, electronic jamming (RAMSES) is used to try to interrupt the weapon's flightpath. As well, the ships have other defensive capabilities. The main gun on the bow deck is primarily an air defence weapon. It is a 57-mm 70 Mk2 Bofors capable of firing at a rate of 220 rounds a minute, reaching as far away as 17 kilometres. This gun fires explosive rounds to fill the air with shrapnel to shred incoming missiles. Close-in weapon systems are the ship's last resort. This additional protection is provided by a Phalanx close-in weapon system capable of firing 3,000–4,500 radar-directed rounds per minute at the threat. The Bofors is therefore the first line of defence, with the Phalanx Gatling gun used as a last resort.

Defence from subsurface threats employs different systems. The ships' light torpedoes allow them to engage a hostile submarine. Two twin 324-mm torpedo tubes are installed near the helicopter hangar. The torpedoes are the Mark 46 lightweight anti-submarine torpedo, smaller than the heavyweight versions carried by submarines. While the ship can use these to attack enemy submarines, they are primarily defensive weapons, since getting close enough to fire them would place the frigate in range of the enemy submarine. Surface ships therefore prefer to attack enemy submarines with their embarked helicopters. A frigate's helicopter extends that range and provides the frigate with its best anti–submarine warfare weapon.

To meet rapidly evolving threats in the maritime world, a modernization of the frigates – the Halifax-Class Modernization/Frigate Life Extension (FELEX) program – was begun in 2010 and completed in 2016. This refit is characteristic of naval ships, and most ships undergo modernization at the mid-point of their expected service. The modernization added state-of-the-art equipment, including new command and communications systems, an upgraded surface-to-surface Harpoon missile system, a new radar suite, and new Sea Sparrow missiles. This $4.3-billion refit brought the ships up to date, improved combat capability and interoperability, and ensured that the frigates remain effective throughout their service life, which will extend into the mid-2030s.

In June 2010, the Canadian government launched the National Shipbuilding Procurement Strategy (now called the National Shipbuilding Strategy), which, among other things, aims to replace the Halifax-class frigates – as well as the capabilities of the retired Iroquois-class destroyers – with up to 15 new warships referred to as the Canadian Surface Combatants (CSCs). This replacement class is currently in the design stage, and construction is anticipated to begin in the late 2020s.

The Kingston-Class Patrol Ships

The Kingston-class Maritime Coastal Defence Vessels (MCDVs) are Canada's lightly armed patrol ships. These vessels undertake a variety of domestic and international missions, guarding the maritime approaches to North America, building partnerships with allies, and performing constabulary and patrol duties.

The Kingston class was designed and built at the end of the Cold War, after being proposed in the 1987 White Paper on defence. Noting that the Royal Canadian Navy (RCN) then possessed "too few operational vessels, very limited capacity to operate in the Arctic, and no capability to keep Canadian waterways and harbours clear of mines," the White Paper elucidated the urgent need to procure new patrol vessels.[163] The Anticosti- and Bay-class vessels were rapidly aging out of operationality, and a new vessel was required to fill the Navy's widening capability gap. The Kingston class was thus born.

Commissioned by Halifax Shipyards Ltd. between 1996 and 1999 under the Maritime Coastal Defence Vessel (MCDV) Project, the vessels were not expected to participate in combat (given the end of the Cold War). Instead, they possessed a general-purpose patrol capability, in addition to modular minesweeping capacities. Desires to make the vessels' construction and operation as economical as possible led to the use of off-the-shelf, commercial equipment in their construction, as well as their inclusion of several design compromises respecting their minesweeping capabilities. For instance, while the design of the Kingston class's propulsion systems sought to minimize their acoustic signatures and reduce their risk of activating acoustic mines, their hulls were fashioned out of steel, rather than the fiberglass or wood more common and preferred among minesweepers to avoid activating magnetic mines.[164]

Displacing 970 tons and measuring 11.3 metres in breadth and 55.3 metres in length, 12 of these small, low-cost patrol vessels now operate across Canada, divided equally between the Pacific and Atlantic. Between 30 and 36 sailors from both the Regular Force and Naval Reserve crew each vessel. Given that the vessels were not intended to fulfill a combat role, the Kingston class was (and remains) only lightly armed. Initially, the vessels had a light armament, namely two .50-calibre/12.7-mm machine guns, as well as a Bofors 40-mm Model 60 Mk 5C rapid-fire gun. This latter gun, affixed to the vessels' forecastle decks, required manual loading and was devoid of any targeting ability, given that its design harkened back to the Second World War. As such, it was deemed obsolete in 2014 and removed from the vessels, leaving the Kingston class equipped with only its machine guns.

Due to this minimal combat or even defensive capability, the RCN has predominantly used its Kingston class as either training vessels or general-purpose patrol vessels, conducting search and rescue, fisheries and resource protection patrols to aid the Department of Fisheries and Oceans, and domestic coastal patrols and surveillance, in addition to supporting other civilian and law enforcement agencies.[165] Though destined primarily for domestic taskings and responsibilities, the Kingston class nevertheless assumed a broader role in the 2000s as the RCN's Halifax-class frigates were undergoing modernization. This broadened and expanded role has since continued. In recent years, the vessels have participated in counter-drug operations alongside the US Coast

Guard and US Navy, such as Operation *Caribbe*, involving the ships in the confiscation and capture of tonnes of illicit marijuana and cocaine.[166]

In addition to these undertakings in the Western Hemisphere, vessels of the Kingston class have also deployed across the Atlantic Ocean to West Africa. For instance, HMCS *Moncton* and HMCS *Goose Bay* partook in Operation *Projection West Africa* in January 2022, then repeating the mission the following year. These operations, consisting of regular four-month deployments, are intended to build relationships and uphold maritime security in the region of the Gulf of Guinea, as well as to engage with West African states to develop partner capacity. HMCS *Moncton* and HMCS *Glace Bay* similarly deployed in the US Naval Forces Africa–led Exercise *Obangame Express 2023*, which sought to boost cooperation among the participant nations and elevate security and safety in the waters of the Gulf of Guinea.

Though the conclusion of the Cold War inevitably reduced the Kingston class's need to participate in minesweeping, international operations have recently called upon the vessels' minesweeping capabilities. In August 2022, HMCS *Kingston* and HMCS *Summerside* were involved in a Standing NATO (North Atlantic Treaty Organization) Mine Countermeasures Group 1 operation seeking to detect and demolish ordnance still remaining in the English Channel from the Second World War. Thus, while now diminished and predominantly theoretical, the vessels' minesweeping capabilities remain one element of the Kingston class's broad and multi-functional role.

Despite their flexibility, versatility, and multi-functional nature, certain design features inherently limit the Kingston-class vessels. As previously mentioned, their dearth of armament restricts them from participating in combat or defence. Given that their design sought to incorporate both patrol and minesweeping functions into a singular vessel, their minesweeping capabilities necessarily came at a cost to their speed, making the Kingston class remarkably slow for a patrol vessel. Indeed, their maximum speed is a mere 15 knots and their range an unremarkable 5,000 nautical miles. Their short hull – selected to minimize their cost – also reduces their speed and compromises their seakeeping ability. Financial considerations similarly resulted in the use of low-carbon and thus inexpensive steel, as well as the construction of the vessels to commercial rather than military standards. In addition to reducing their utility as minesweepers, this decision, too, restricts the speed of the Kingston-class patrol vessels.[167]

Now, decades of use and age have placed further limitations on the Kingston class's utility and functionality. As the vessels approach three decades of use, chronic engine troubles are common, maintenance is becoming increasingly expensive, and crewing the vessels presents a growing challenge on account of the RCN's enduring personnel shortages. Various conversations regarding the prospective modernization or outright replacement of the vessels have cropped up over the years, including a planned $100-million mid-life refit, which the Government of Canada cancelled on account of the costs and limitations of the vessels.

As of 2024, the RCN is seeking the procurement of a new fleet of coastal patrol vessels. However, a funded capital equipment procurement project has yet to be successfully advanced. While the Standing Committee on National Defence recommended a similar procurement in 2017, the Government of Canada rejected the notion of replacing the Kingston class on a ship-for-ship basis. In its place, the government insists that the new Arctic and Offshore Patrol Vessels (AOPVs) being

delivered under the National Shipbuilding Strategy will be able to assume several of the Kingston class's traditional roles and indeed offer a "more complete set of capabilities."[168]

Critics of this plan, however, contend that since the RCN is only set to receive six AOPVs, compared to its 12 Kingston-class vessels, the consequent reduction in the size of its fleet will inevitably curtail the RCN's capacity. Moreover, though the Canadian government announced in July 2023 its awarding of a $450-million contract to Thales Canada Inc. and Thales Australia Ltd. for the provision of in-service support to Canada's Minor Warships and Auxiliary Vessels (including the Kingston class),[169] the corresponding solicitation documents noted that the government had yet to reach a decision regarding the Kingston class's future. Until such a decision is finalized, the Kingston class will continue to provide the RCN with small patrol vessels that can perform a variety of functions and operational missions, even as several elements of their original design restrict their capabilities.

The Arctic and Offshore Patrol Vessels

The Arctic and Offshore Patrol Vessels (AOPVs) – called the Harry DeWolf class – are ice-strengthened patrol ships (not icebreakers) designed to extend the Royal Canadian Navy's (RCN) reach deeper into Arctic waters, expand the operating season there, and provide the Navy with new capabilities in a range of global defence and security missions.

The plan for their construction was first announced in July 2007, and the AOPVs were subsequently included in the National Shipbuilding Procurement Strategy (now the National Shipbuilding Strategy (NSS)) announced in 2010. The AOPVs were assigned to the combatant class of vessels as part of the large ship projects within the Strategy, as announced in 2011. Irving Shipbuilding Inc. was selected for the largest portion of the new work assigned, consisting of six to eight AOPVs and the Canadian Surface Combatants (CSCs). The AOPV Project was sequenced to precede the CSC Project, as this was seen as a logical point to reestablish Irving as a world-class, modern shipyard through the investments in people, infrastructure, and processes and procedures, starting with the smaller and less complex vessels being constructed and delivered first. An AOPV contract was signed with Irving in Halifax in 2015, with construction of the first of the class booked to begin in September 2015. The number of AOPV vessels was initially reduced to five vessels, with an option for a sixth, but in November 2018, the government announced that the sixth ship would proceed. In December 2018, it was announced that two additional AOPVs would be built for the Canadian Coast Guard, with the same basic design and minor deviations from the RCN vessels.

The first ship of the class, the future HMCS *Harry DeWolf*, departed Irving's Halifax Shipyard in November 2019 and, using its diesel-electric engines, moved to the Bedford Basin to commence initial builder's sea trials. These trials encompassed anchor handling, testing the integrated bridge and navigation system, fin stabilizers, Multi-Role Rescue Boat launch and recovery, and trials of the communication systems. On November 23, 2019, the future HMCS *Harry DeWolf* left Halifax harbour for the first time to continue with builder's sea trials. After the successful completion of the trials, the ship was transferred to the RCN on July 31, 2020, and commenced naval sea trials. In the winter of 2021, the ship made its first voyage north for cold weather and ice trials, performing very well. In June 2021, HMCS *Harry DeWolf* was commissioned into service with the RCN.

HMCS *Harry DeWolf* began its first major operational deployment in August 2021. The ship circumnavigated North America, starting from Halifax, going through the Northwest Passage, then proceeding southward along the Pacific Coast and through the Panama Canal, thence northward back to Halifax. HMCS *Harry DeWolf*'s transit of the Northwest Passage in the summer of 2021 was the first RCN transit of the Passage since HMCS *Labrador* in 1954.

The second of the class, HMCS *Margaret Brooke*, was commissioned in October 2022 following a comparable series of builder's and naval sea trials and tests. Prior to commissioning, in September 2022, HMCS *Margaret Brooke* was tasked to provide support to hurricane relief efforts, after Hurricane Fiona's devastating impact on the Atlantic provinces. The vessel provided damage assessments and welfare checks to the most impacted communities along the south coast of Newfoundland, where water access was the only means of accessing these villages and outports.

On May 29, 2022, there was an official joint naming ceremony for *Margaret Brooke* and *Max Bernays*, the third ship of the class. The future HMCS *Max Bernays* was delivered to the RCN in September 2022 for final post-acceptance trials and is scheduled to be the first Pacific-based ship in the class, arriving in Esquimalt, British Columbia, in May 2024. The fourth AOPV, HMCS *William Hall*, was launched in November 2022 and was handed over to the RCN in August 2023.

The full class of AOPVs will include the following:

- HMCS *Harry DeWolf* (AOPV 430)
- HMCS *Margaret Brooke* (AOPV 431)
- HMCS *Max Bernays* (AOPV 432)
- HMCS *William Hall* (AOPV 433)
- HMCS *Frédérick Rolette* (AOPV 434)
- HMCS *Robert Hampton Gray* (AOPV 435)

These vessels are designed as versatile patrol ships, capable of a wide spectrum of safety and security missions. Canada's 2017 defence policy, *Strong, Secure, Engaged*, notes that the ships will perform surveillance in Canadian waters, especially in the Arctic, as well as enforce sovereignty and provide the government with information about activities in Canadian waters. According to the RCN's 2015 Concept of Use, the vessels have several specific missions:

- search and rescue;
- support for other government departments (for example, fisheries or border services);
- maritime domain awareness (to ascertain who is in Canadian waters and what they are doing);
- assistance to law enforcement (for example, smuggling);
- aid to civil power (for example, assistance dealing with an oil spill in the Arctic);
- logistical support to the Canadian Armed Forces and other government departments (for example, transport of equipment or personnel for disaster relief assistance operations); and
- sovereignty protection.

At 103 metres long and 6,615 tonnes, the AOPV will be the largest ship in the RCN until the delivery of the Joint Support Ships (JSSs). Despite their large size, they carry a small crew of 45, with the capacity to support up to 40 additional embarked personnel. As noted, the ships are not icebreakers, but they are designed for Arctic operations. The AOPVs meet the Polar Class (PC) 5+ ice requirements of the International Association of Classification Societies (IACS), with a Polar Class 4 bow, allowing them to travel through one metre of ice. They can also carry multi-purpose rescue and assault boats, as well as pick-up trucks, all-terrain vehicles, and snowmobiles in the vehicle bay. The helicopter deck is large enough to support the CH-148 Cyclone maritime helicopter (though for Arctic operations it may typically embark smaller Griffon helicopters) and can operate a variety of uncrewed aerial vehicles. The AOPV can also be integrated with payloads such as underwater survey equipment and will have space designed for shipping containers. A 20-ton crane has been fitted to make the ship self-sufficient for loading and unloading equipment.

While armed, the AOPVs are not intended to engage in direct combat. The ships have a BAE Mk

38 deck gun designed for constabulary rather than warfighting duties. The decision to arm these ships so lightly is based on the threat assessment in the Arctic and in expected patrol areas. Thus, rather than warfighting, these ships will focus on monitoring, policing, maritime presence, surveillance, and assisting civilian and commercial activities. These are the low-risk, high-probability security threats that are expected to emerge with the increased use and development of the Arctic.

The primary role for the AOPVs will be operations in the Arctic. To exercise sovereignty in the North, Canada needs to maintain presence and illustrate functional control and stewardship. This is accomplished by enhancing the ability to operate in the region, manifested in increased awareness as well as response and support capabilities. The AOPVs will greatly improve the RCN's ability to monitor activity in the region and support other government departments as their responsibilities expand due to the increased activities in the region as a result of the melting of Arctic ice. This support work may include hydrographic surveying with the Canadian Hydrographic Service, fisheries patrols with the Department of Fisheries and Oceans, and constabulary operations with the Royal Canadian Mounted Police (RCMP). Because they are not icebreakers, the AOPVs will redeploy south during most of the winter months.

Outside the Arctic, the AOPVs will be deployed on a wide range of patrol and surveillance duties, as well as humanitarian/disaster assistance response missions in Canada and overseas. Operating off foreign coasts in a support capacity will be made easier by the ships' ample space for cargo and civilian support personnel, and the AOPVs will work in conjunction with the future JSSs to deliver supplies and assist responders ashore.

For missions such as fisheries patrols, surveillance, and interdiction of smuggling/narcotics operations, the AOPVs can be more effective and less costly than employing combatant warships. The AOPVs are less expensive to operate and have much smaller crews than the Halifax-class frigates. The ships' size and space for additional personnel also make them ideal platforms for maritime naval scientific research. As such, the Harry DeWolf class will support the activities of Defence Research and Development Canada, as well as government efforts in scientific research and development, while also being able to respond to academic and industry requests.

It should be noted that – like most new classes of ships – the Harry DeWolf class has experienced teething problems. In addition to malfunctions of its fire suppression system, freshwater generator, and communication system, there have been problems with the diesel generators in HMCS *Harry DeWolf*. Such challenges are to be expected when delivering a new class of warship. In August 2022, HMCS *Harry DeWolf* set sail to participate in an exercise in Canada's North, but it was forced to return to Halifax because of issues with its diesel generators. The malfunction was linked to the engine cooling system and also affected HMCS *Margaret Brooke* and HMCS *Max Bernays*. Also, HMCS *Max Bernays* has had problems with its bow thruster, the system that allows the ship to manoeuvre laterally and therefore is important when berthing and unberthing. The ships remained alongside in Halifax in 2023 until the repairs were made, and all returned to service in 2024. In late 2023, HMCS *Harry DeWolf* completed a successful Great Lakes deployment and delivered the Grey Cup to Hamilton prior to the 110th edition of the game. Regrettably, soon after the Grey Cup delivery, the ship's company encountered an outbreak of COVID-19, which forced the ship to quarantine and cancel some of the planned port visits before returning safely to Halifax.

On January 12, 2024, HMCS *Margaret Brooke* departed for a six-week deployment on Operation *Caribbe*. Led by the United States, this multi-national deployment marks Canada's contribution to the enhanced counter-narcotics operations focused on strengthening safety and security in the Caribbean region.

The AOPVs are intended to buttress Canada's sovereignty in the North. They are an important tool in enforcing the laws and regulations in the Arctic respecting shipping, the environment, fishing activities, and resource management, as well as by providing a military presence. They can also fulfill other vital roles in support of Canadian government objectives beyond the Arctic. The RCN has seen both qualitative and quantitative improvements in each new AOPV ship coming into service. There are issues to resolve, of course, but this is a natural part of the shipbuilding process.

The Protecteur Class

As a trading nation that conducts much of its international trade by sea, Canada is heavily reliant on the stability of the world's seas and the dominance of the rules-based international maritime order. Increasingly, this stability and order appear to be under siege, as evidenced by Russia's escalating hostility and aggression, as well as China's progressively more domineering and militant approach to the East and South China Seas. Together, these have reinforced the need for deterrence and the importance of Canada and its allies maintaining an international presence in the maritime theatre.

This need to bolster international stability and support the maintenance of the international maritime order has led Canada to develop what its naval operational strategy, *Leadmark 2050*, identifies as a "blue-water navy"[170] and a "globally deployable" force[171] in its Royal Canadian Navy (RCN). Such global deployments and blue-water operations require considerable support to be effective and broad in their reach. In the RCN, Auxiliary Oiler Replenishment (AOR) ships have traditionally provided this critical support, accompanying warships to supplement and restock their fuel (both aviation and marine), ammunition, food, fresh water, and other essential supplies. Serving as essentially "a floating grocery store, gas station, maintenance and sparing repair shop, and helicopter hangar," the AORs – for most navies – are support vessels rather than combat units. As such, they are typically lightly armed, generally only boasting light automatic cannons, machine guns, small arms, and/or self-defence systems like the Phalanx Close-In Weapon System (CIWS).

HMCS *Protecteur* and HMCS *Preserver* were, until recently, Canada's two AORs. Commissioned in 1969, HMCS *Protecteur* suffered a significant fire in February 2014 and was subsequently paid off the following year. HMCS *Preserver*, commissioned in 1970, was paid off in 2016. With both vessels thus retired, the RCN found itself facing a significant capability gap in its lack of any indigenous ability to support its fleet.

Leasing at-sea support services from Canada's allies in part addressed this capability gap. So, too, did the Government of Canada's leasing arrangement with Quebec's Chantier Davie shipyard to convert a commercial container vessel into an interim replenishment vessel. As a result of this so-called Project Resolve, the Interim Auxiliary Oiler Replenishment (iAOR) ship MV *Asterix* has offered critical support to the Canadian navy and enabled it to maintain a global reach. Plans for a more permanent replacement for the AORs date back to 1999 and the Afloat Logistics Support Capability (ALSC) project, which ultimately failed to progress. The subsequent Joint Support Ship (JSS) project, which advocated for the construction of three new AORs with an added afloat joint command and control ability, as well as a limited joint communication system, also failed to advance, due to its cost. However, the creation of the National Shipbuilding Strategy (NSS) rejuvenated the JSS proposal. Under the NSS, the shipyard selected to construct the non-combat vessels under the Strategy would also undertake the construction of the JSSs. The majority of the limited joint capabilities for the prospective JSSs were removed from their operational needs, and although the NSS includes the option for the procurement of a third JSS vessel, costs make it unlikely that a third JSS will indeed be ordered.

The design for the JSSs thus under construction is premised upon the design of the German Berlin EGV class, with certain modifications to account for distinct Canadian and RCN needs. In addition to modifications due to the different electrical standards between North America and Europe, there have also been adjustments to the arrangements and structures of the base design's Main Radio Room, Combat Information Centre, and Machinery Control Room. Other design changes include magazine changes, the removal of a Forward Refuelling Station, the internal reorganization of the medical complex and accommodation standards, the integration of the Canadian Replenishment-at-Sea equipment and arrangement supplier, improved insulation, and the use of GL D-grade steel to satisfy the Lloyd's Register's specifications for winterization. Other design modifications have focused on reinforcing and bolstering the flight deck, adjusting the hangar, and incorporating Canada's helicopter traversing and recovery systems, all of which will ensure the JSSs' capacity to accommodate Canada's heavier and larger CH-148 Cyclone helicopters.

Originally, the JSSs were earmarked to reach full operationality in 2019. However, construction is significantly behind schedule. Interruptions due to the COVID-19 pandemic caused delays, as did issues with the sequencing and order of the vessels being constructed at Seaspan Shipyards in British Columbia. The NSS had initially anticipated and provided for the construction of the JSSs at Seaspan to occur after the shipyard had completed construction on the Offshore Oceanographic Science Vessel (OOSV) and Offshore Fisheries Science Vessels. An existing production gap at Seaspan and desires to expedite this schedule resulted in the shipyard commencing construction of large parts of the first JSS in June 2018. However, schedule slippage and complications with shuffling the shipyard's capacity led the Canadian government to reorder Seaspan's construction sequence in early 2019. Now, construction will prioritize the completion of the future HMCS *Protecteur* (the first JSS), then the OOSV, and finally the future HMCS *Preserver* (the second JSS). This adjustment has seemingly accelerated progress on the JSSs' construction. January 2020 saw Seaspan laying the keel of HMCS *Protecteur*,[172] the shipyard announced in March 2023 that it had crane-hoisted the mast section onto the future vessel, and the hull was reportedly in one piece as of April 2023. This first JSS launched in December 2024 and is expected to be commissioned in late 2025.[173] Meanwhile, construction commenced on the future HMCS *Preserver* in May 2022, with the vessel reportedly being likely to be delivered to the RCN in 2026.[174]

The construction of these JSSs is in part such a trial and such a feat because of their enormity. Measuring over 24 metres in width and 173 metres in length, the JSSs, once complete, will constitute the largest naval vessels ever constructed in Canada. With a top speed of 20 knots and approximate cruising speed of 15 knots, the vessels' range will be around 10,800 nautical miles. Their capabilities, too, will be significant. They will be able to effect the solid and liquid replenishment of allied and Canadian vessels, in addition to performing the at-sea maintenance of helicopters and vessels. The JSSs will be capable of responding to nuclear, biological, and chemical threats, as well as enhancing humanitarian responses by providing sealift capacities, mobile command posts, and medical facilities. Given that Seaspan is constructing the vessels to military standards, and equipping them with advanced self-defence and damage control systems, the JSSs will be able to fulfill these various roles in a range of threat environments. Thus, Canada's future Protecteur class, constructed under the Joint Support Ships program, will continue to provide the RCN with the AOR capabilities required to sustain its crucial blue-water capacity and global deployments.

Canadian Maritime Aviation: Missions and Capabilities

Maritime aviation is central to the operations of naval forces. While such aviation is encompassing more drone operations, it still revolves around rotary-wing (helicopters) and fixed-wing (airplanes) assets. These platforms conduct missions from either the shore or from aboard vessels plying the waters. Both fixed- and rotary-wing aircraft supplement naval capabilities and enhance a navy's capacity to perform a variety of functions and missions. First, a navy's use of maritime aviation enhances its domain awareness. When aviation assets are attached to a warship, they enable the vessel to expand its sensing far beyond the horizon. As surveillance assets, aircraft can also travel much faster than a vessel, and cover more area, making them particularly useful for determining the presence and location of hostile forces (or criminal forces, if engaged in counter-narcotic or counter-piracy operations). The speed and range of maritime aviation assets also facilitates search and rescue (SAR) operations. The ability of aircraft to transmit real-time data and information directly to vessels through data links has further enhanced the capacity of such assets to perform critical reconnaissance and surveillance functions in support of naval operations.

In addition to this ability to vastly expand a vessel's surveillance over the horizon, helicopters also constitute capable anti-submarine warfare (ASW) assets. Notably, modern helicopters have tremendous submarine-detection capabilities. Equipped with sonobuoys (radio transmitters and acoustic receivers affixed to a buoy that can be dropped from a helicopter or fixed-wing aircraft) or a "dipping sonar" (a transducer attached to a long cable that thus enters the water as the helicopter hovers above the surface and utilizes sound pulses to detect objects), they are capable of identifying submarines and transmitting that data back to the vessel. Moreover, in addition to identifying submarine threats, helicopters also can directly engage with those threats with their own weapons. For instance, Canada's Cyclone helicopters can carry two MK-46 anti-submarine torpedoes. They are also equipped with jammers and flares for self-defence.

From a logistical standpoint, ships equipped with a helicopter also benefit from the aircraft's ability to transport material ashore, particularly in situations in which the vessel is unable to dock, due to security concerns or the absence of facilities altogether. For instance, when the Royal Canadian Navy (RCN) was dispatched to Somalia in 1992 to support a United Nations mission, vessels were unable to dock in Mogadishu, as the port was not secure. As a result, the transportation of supplies ashore for the Canadian Army units stationed in Somalia relied on the ship-based helicopters. Similarly, in the aftermath of the 2010 earthquake in Haiti, water, supplies, personnel, and the Disaster Assistance Response Team were frequently transported via helicopter, given that the port facilities available to the RCN were either destroyed or insufficient. Otherwise, helicopters are also capable of performing medevac or medical evacuation operations, transporting divers to a scene, and conducting aid-to-the-civil-power operations in support of other Canadian government departments.

For the RCN, maritime airpower is provided by both fixed-wing and rotary-wing aircraft, operated by the Royal Canadian Air Force (RCAF). Since the RCN no longer possesses aircraft carriers, fixed-wing aircraft are operated from the shore. In Canada, this fixed-wing, shore-based maritime aviation asset is provided by its Maritime Patrol Aircraft, namely its Aurora (CP-140). These aircraft are principally tasked with ASW and maritime situational awareness. They are also capable of providing vital aid in maritime SAR responses, performing sovereignty patrols, monitoring

fisheries, and conducting surveillance in the Arctic. As Canada's sole intelligence, surveillance, and reconnaissance (ISR) aircraft, the Auroras are thus responsible for undertaking a variety of long-range operations over the maritime, land, and littoral regions. Both the Aurora Incremental Modernization Project (AIMP, aiming to update their technology and electronics) and the Aurora Structural Life Extension Project (ASLEP, upgrading their body and framework) were completed by 2022. A future replacement comes in the form of the P-8A Poseidon, which were purchased by Canada in 2023, with the first delivery expected in 2026.

For over five decades, the RCN's rotary-wing asset was the Sea King (CH-124) helicopter.[175] Having come into service in 1963, it has since been retired and replaced with the CH-148 Cyclone, which successfully completed its first operational deployment for the RCN in 2018. While the Cyclones' incorporation into the RCN has not been seamless, marked by the tragic loss of six CAF personnel when one of the helicopters crashed in April 2020,[176] the helicopters have provided an undeniable boost to the RCN's maritime aviation capabilities. Their communication systems are vastly improved over those of their predecessors, in some respects surpassing those of the vessels from which they operate. They are capable of undertaking operations around the clock and in poor weather, aided by auto-tracking and infra-red technologies. They can perform over-the-horizon targeting and, thanks to their long-range radar, can acquire a complete image of a contact up to 200 miles ahead, with far superior resolution on the consequent signals. The Cyclones are also able to detect submarines at significantly greater ranges than the Sea Kings before them.

While the RCN expands and modernizes its traditional maritime air assets, it will certainly look to broaden its fleet in new directions as well. Uncrewed surface vessels, subsurface vessels, and aerial vehicles will undoubtedly be brought into service. The CU-170 Heron uncrewed aerial vehicle (UAV) has already been in use in the RCN for several years, and the integration of such assets will only quicken as the UAVs become more capable. Developments in autonomous technology, too, will provide access to further maritime aviation capabilities and options. As such, the relevance of maritime aviation assets – and navies' reliance on them – will only increase further in the coming years.

MV Asterix

Though distant water operations are oftentimes central to a navy's operational mandate, they can pose unique logistical challenges, particularly the resupply and refuelling of the naval vessels involved. While warships undertaking independent operations may in some instances be able to rely on allied vessels for resupplies, or on contractual agreements permitting them to visit foreign ports to purchase supplies and fuel, activities in remote or less friendly regions can be more difficult. In these cases, where there are few onshore reprovisioning and resupply options and where the presence of allied vessels is negligible, the need to supplement fuel and other supplies can present a critical planning factor and indeed limit operational capacities. Such logistical issues can even challenge the Canadian navy's domestic operations, given the sheer size of the country and vast geographic dispersal of its population. Consequently, navies need supply vessels to enable the sustainment – and, thus sustained operations – of warships. The majority of medium and large navies internationally therefore maintain vessels expressly and deliberately designed for this purpose, to enable the provision of fuel (both marine and aviation), maintenance equipment, ammunition, spare parts, personnel, and provisions like medical supplies and food to other naval vessels while underway and at sea. Such vessels are known as Auxiliary Oiler Replenishment (AOR) ships, and their resupply operations are referred to as Replenishment at Sea (RAS) missions.

RAS operations are inherently sophisticated and intricate, requiring delicate manoeuvring at sea. First, the AOR and the receiving ship, or the vessel requiring the resupply, must move alongside each other, on a parallel speed and course. Since doing so necessitates that the vessels manoeuvre into close proximity of each other, with a lateral distance of 80 to 120 feet to permit the passing of lines between them, even this initial and basic component of the resupply requires significant skill and precision. The lines subsequently transferred between the ships allow them to be connected by the automatically tensioned span wires dispatched by the supply ship, in which traveller blocks pass between the vessels, and fuelling lines with couplings or probes are employed to facilitate liquid transfers. Ammunition and heavier stores items are delivered on pallets on the vessels' upper decks via pallet movers and forklift vehicles, after which the cargo is expediently moved from the embarkation point to the dispersal areas and below deck. Once the vessels are connected via a tensioned span wire, and all connections are established, the transfer begins, and the lateral distance between the vessels can be increased to 120 to 140 feet, depending upon the prevailing sea and wind conditions.

Occasionally (and if the teams are adequately trained), the AOR supply ship may accelerate its resupply of the receiving ship by operating three replenishment stations concurrently – for instance, transferring light-weighted stores and mail as well as personnel at a forward station, liquid cargo like water and fuel at a midships station, and heavy stores and/or ammunition at an after station. In other cases, the supply ship may perform two ship transfers simultaneously, with one receiving ship on its starboard side and another on its port side, in order to hasten the broader resupply operation. The North Atlantic Treaty Organization (NATO) has, over the years, honed and standardized the equipment, procedures, and communications protocols involved in such RAS operations, with regular exercises seeking to develop and maintain proficiency.

Such operations remain delicate and intricate procedures, particularly since they occur around the clock and in diverse sea and weather conditions. A further challenge comes from the fact that, given the inability of both the receiving and supply ships to manoeuvre while an RAS operation is underway, the vessels involved in a resupply are vulnerable and susceptible to hostile action. Thus, cautious planning, precise and reliable seamanship, and an attention to both safety and speed are all integral factors for the successful completion of an RAS mission.

For the Royal Canadian Navy (RCN), RAS missions were, until recently, the responsibility of two AORs, namely HMCS *Protecteur* and HMCS *Preserver*. Both vessels have since reached the culmination of their lifespans, with the last retired in 2016. While plans have existed since 1999 to construct new AORs for the RCN, persistent delays and unsuccessful procurements left the Navy without a singular AOR capable of effecting a resupply or refuelling. Since solely relying on allies for refuelling is undesirable if not entirely untenable, the RCN was compelled to explore other alternatives to temporarily rectify this capability gap, until the Joint Support Ships (JSSs) planned under the National Shipbuilding Strategy (NSS) are constructed and commissioned. As such, the RCN held a briefing in January 2015, noting its intention to lease "At Sea Support Services" while it awaited the delivery of its JSSs. Several companies tabled proposals, including Federal Fleet Services. Its proposition to convert a commercial container ship into an AOR was ultimately the successful bid. Under this proposal, an existing vessel would be converted into an AOR at Quebec City's Chantier Davie (rather than constructing a new vessel), and the newly refitted AOR would be leased by the government (rather than being a naval vessel). It was, seemingly, a comparably inexpensive and expedient interim solution to a significant capability gap.

A Canadian commercial container ship launched in 2009 called MS *Asterix* was selected for conversion into the interim AOR ship. Following its 2015 arrival at the Chantier Davie shipyard, *Asterix* was unveiled on July 20, 2017, in a public ceremony complete with the traditional shattering of a champagne bottle.[177] Sea trials were conducted the following November, the vessel arrived in Halifax on December 27, 2017, and *Asterix* was officially accepted into the RCN's service in March 2018 after successfully completing further sea trials. The delivery of MV *Asterix* was groundbreaking on multiple levels: not only was it delivered on time and on budget, as Chantier Davie triumphantly proclaimed, but its delivery also marked the RCN's receipt of the first new supply vessel in nearly five decades. Initially, the plan was for the Canadian government to lease the vessel for a five-year period, at around $65 to $75 million annually,[178] while the JSSs were constructed, with the five-year lease contract thus being signed in 2018. However, when serious delays pushed the first JSS's anticipated delivery to after the lease contract's expiry, discussions ensued with Federal Fleet Services in July 2022 to extend the lease further until January 2025. The consequent two-year extension to the government's contract to lease MV *Asterix* was announced in February 2023, and it was announced in August 2024 that the Government of Canada had further extended its contract for an additional three years.[179]

MV *Asterix* is a significant vessel at 182.5 metres in length and 26,000 tonnes in displacement, making it the largest vessel in the RCN.[180] Capable of handling both solid (spare parts, food, and equipment like vehicles and ammunition) as well as liquid (water, aviation fuel, and diesel) cargoes, *Asterix* is furthermore equipped with a helicopter flight deck and the certification required to accommodate the Griffon and Cyclone helicopters. Though small, its hospital is well supplied,

boasting dental facilities, X-ray capabilities, and the personnel needed to staff a surgical suite. This hospital services the crews of receiving vessels, as well as the 36 civilian personnel and up to 114 naval personnel that crew MV *Asterix* itself (a 67-member detachment aboard *Asterix* is devoted specifically to replenishment duties).[181] The RCN crewmembers aboard MV *Asterix* are referred to as Naval Replenishment Unit (NRU) *Asterix*. While these naval personnel conduct the RAS operations, decide on the operations to be undertaken, and are responsible for security and helicopter operations, personnel from the Federal Fleet Services maintain and operate the vessel, providing hotel services, cleaning, and food.

A particularly notable feature of MV *Asterix* is its double hull, which offers further protection to the vessel and its cargo, satisfies environmental regulations, and enables the vessel to call at ports where compliance with such environmental regulations is mandated. This is a feature that the RCN's previous AORs did not possess and that thus restricted them from operating in certain states' waters and refuelling in particular ports.[182] Moreover, MV *Asterix* has also joined the Green Marine, a voluntary environmental certification program within the North American maritime industry, making it the first naval oiler to participate in the program.[183] With its ability to hold 28 shipping containers and accommodate up to 350 passengers, MV *Asterix* also possesses a notable capability to partake in humanitarian or natural disaster relief operations. However, the vessel is not without its limitations. Given its commercial design, *Asterix* has limited survivability in combat and is at higher risk in conflict zones. Moreover, it does not have any self-defence weapon systems, although provisions for such systems exist if they become imperative. Together, this dearth of a self-defence weapon system and the vessel's nominal survivability in combat restrict the operational situations into which it may be deployed, prohibiting its use in regions experiencing or exposed to combat.[184]

Asterix entered service in 2018, and that year offers a good illustration of the ship's tasks. It was engaged and deployed for nearly the entire year, transiting 51,062 nautical miles (to, for instance, Hawaii, Vietnam, Australia, Guam, and the South China Sea). It distributed 20 million litres of fuel at sea during 138 supply operations alongside nine allied navies.[185] The vessel underwent maintenance work in early 2020 and engaged in a variety of exercises, including Exercise *Joint Warrior* – the most sizeable military exercise conducted in Europe – in October 2020. *Asterix* has continued to enjoy regular deployments in the years since. In September 2021, it was a participant in Exercise *Cutlass Fury*, an exercise that Canada organized off the Atlantic Coast. It departed from Halifax for the Pacific in March 2023, alongside HMCS *Montréal*, and returned to Esquimalt, British Columbia, in December 2023 with HMCS *Ottawa* and HMCS *Vancouver* after a deployment to the Indo-Pacific region, concluding its 126 days away from Canada. Until the two JSSs are constructed, commissioned, and entered into service, MV *Asterix* will, in all probability, remain active as a vital support asset for the Royal Canadian Navy.

Naval Tactical Operations Groups

The Royal Canadian Navy (RCN), as a globally deployable and blue-water navy with a stake in preserving the security and safety of both Canadian and international waters, has long found a need to participate in boarding operations. While boarding operations in wartime may seek to seize control of a vessel, such missions in peacetime may involve authorized personnel boarding a ship for a certain, specified objective.[186] Indeed, investigating and responding to sanctions contraventions, drug trafficking, or smuggling often requires boarding merchant ships that are transiting to or from particular regions to examine the vessel's cargo to ensure it does not include passengers, drugs, or weapons that either do not appear on the ship's manifest or that violate international law. As such, boarding teams regularly perform inspections of such "vessels of interest," confirming identities and scrutinizing the cargo. Although rare, such activities can encounter resistance.

For the RCN, boarding parties have historically been composed of regular crew members for whom participating in boarding missions comprises a secondary duty. While boarding remains a part-time duty in the RCN, the need for a more intensively trained and dedicated force has become apparent, particularly during Canada's participation in Operation *Artemis*, the maritime security and counter-terrorism operation in the Middle East. While boarding teams could be called upon to inspect a fishing vessel in the Arabian Sea, they could also encounter Somali pirates armed with rocket-propelled grenades or AK-47 machine guns, or a boat carrying an armed crew guarding its illicit substances.[187] The possibility of encountering such vessels clearly called for better-trained boarding teams.

As a result, in 2014, Vice-Admiral Mark Norman, then the commander of the RCN, authorized the formation of the Maritime Tactical Operations Groups (MTOGs). Now called the Naval Tactical Operations Groups (NTOGs), these groups are intensely trained, specialty boarding teams that are designed to partake in more dangerous missions. The first ten-crewmember team sailed aboard HMCS *Winnipeg* in June 2015 to partake in counter-narcotics operations in the Caribbean Sea, followed by the Canadian mission in support of North Atlantic Treaty Organization (NATO) objectives in the Mediterranean. Since that time, NTOG teams have deployed twice annually on six-month tours, typically in regions like the southern Mediterranean, Horn of Africa, or Gulf of Guinea, in which a resisted boarding could be possible.

Personnel seeking to become involved in the unit must undergo a challenging five-day selection process, involving "a rigorous physical and mental selection process."[188] Successful candidates then undertake the three-month Naval Tactical Operators Course (NTOC), which provides instruction in hand-to-hand combat, close-quarters battle, improvised explosive device (IED) identification, tactical shooting, and advanced medical procedures. The first operator selection phase under the NTOG took place in early 2014, and the inaugural class graduated in March 2015.

Upon graduation, these teams deploy on Canadian warships. They are equipped with special equipment, including significantly modified rigid-hulled inflatable boats (RHIBs). Referred to as special operations RHIBs, these are faster boats than typical navy RHIBs, and they are fitted with more manoeuvrable radar and advanced electronics. While this manoeuvrability and speed are not

necessary for standard inspections, they are instrumental if the NTOG is required to pursue a fleeing vessel.

When not deployed at sea, the teams train at the Close Quarters Battlehouse (CQB). A simulated battlespace measuring 2,000 square feet, located at the Albert Head grounds at Canadian Forces Base (CFB) Esquimalt, the Battlehouse is composed of adjustable doors and plywood walls that are capable of withstanding non-lethal munition strikes and that are resistant to water, gas, and smoke damage.[189] This continued training ensures that the NTOG teams remain capable of deploying on RCN vessels in support of the vessels' boarding teams and operations in more dangerous and threatening waters. These versatile and small groups are anticipated to grow in number in the years to come, with the RCN aiming to involve approximately 104 personnel in its NTOG teams by 2025.

Uncrewed Technology in the RCN

Uncrewed systems have, for many years, had the potential to reshape the conduct of naval operations and naval warfare. With the burgeoning interest in the technology producing rapid developments in the past decades, militaries across the world have increasingly been incorporating and adopting uncrewed systems into their forces. Regular reports of new exercises and tests seeking to evaluate and assess the utility of uncrewed aerial vehicles (UAVs), uncrewed underwater vessels (UUVs), and uncrewed surface vessels (USVs) speak to the growing integration of such systems into the suite of war technologies available for enhancing defence and waging war. This trend was radically accelerated by the war in Ukraine. In the Black Sea, the Ukrainian employment of these systems has (as of 2024) effectively driven the Russian surface fleet from the sea. Having sunk several major vessels and repeatedly attacked the anchorage at Sevastopol, the Russian Navy has hunkered down in port in the eastern Black Sea, far from the critical shipping lanes.

In Canada, these developments have had an impact, and the Canadian Armed Forces (CAF) has directed new attention to the role such uncrewed systems might play in supplementing its military capabilities. Uncrewed aerial vehicles have been a component of the CAF's toolbox for several years. The War in Afghanistan, for instance, saw the CAF testing various unarmed models, including the CU-161 Sperwer, which the CU-170 Heron and ScanEagle later replaced. Today, the CAF deploys such UAVs to fulfill various functions, ranging from conducting long-range targeting and surveillance to performing ground attacks, with their value as surveillance tools eliciting particular attention and recognition. However, although much of the CAF's focus for UAVs has concentrated on their utility for air and ground forces, such systems also offer significant benefits and value for maritime forces.

For the Royal Canadian Navy (RCN), the surveillance capacities of such systems are particularly attractive, given their ability to facilitate long-range surveillance and extend a vessel's situational awareness far beyond the range allowed by its onboard sensors alone. Historically, such an expanded situational awareness and surveillance range would have required helicopters departing from warships or planes flying from aircraft carriers, both of which are far more expensive and less sustainable alternatives compared to the modern UAV. Moreover, the diversity of UAVs available today allows for their dispersal across a fleet in accordance with the vessels' individual capacities, with larger ships able to carry several sizeable UAV systems, while smaller ships can still benefit from the provision and use of lighter and smaller UAVs. UAVs thus not only offer enhanced surveillance and situational awareness capabilities for vessels of the RCN, but their availability in an array of models and classes enables significant flexibility for their deployment among the fleet.

However, as much as UAVs offer benefits over helicopters or planes as platforms for extending surveillance capabilities and situational awareness, they also suffer from several of the same limitations. Inevitably, their use is restricted to the availability of personnel to operate and maintain the systems. Since vessels are not always able to accommodate additional crewmembers specifically for the operation of UAV systems, existing crewmembers may necessarily be required to assume the further tasks and responsibilities associated with their operations. Similarly, UAV operations are dependent upon sea and weather conditions, with small UAVs being particularly

susceptible to winds. Deconflicting air traffic in the region of operations is another consideration. It is imperative for RCN vessels utilizing UAVs to be cognizant of civilian air traffic and other maritime military air assets in the operational theatre, to ensure that their systems are not interfering with such traffic. This can restrict their utility for certain RCN vessels not equipped with the ability to conduct air traffic management.

Still, despite these limitations, the RCN has been incorporating UAVs into the fleet for several years. Since its trial deployment from 2012 to 2014, the ScanEagle system has been operated from the RCN's frigates, augmenting the vessels' surveillance capabilities and therefore allowing for the interception of several suspicious vessels, as well as the seizure of prohibited drugs while participating in counter-drug operations. The Snyper micro-UAV has also proven valuable for the RCN in simulating attacks on naval vessels, to train personnel to confront and respond to assaults from singular or several UAVs. The RCN has similarly been utilizing the Puma Maritime Miniature Unmanned Aircraft System (MMUAS) on its Kingston-class vessels since 2019, making it the first uncrewed aerial system (UAS) project to be operated and maintained as the RCN's own capability.[190] Able to remain airborne for around two hours and fly at a maximum altitude of 3,200 metres (10,500 feet), with a 20-kilometre range, the Puma is able to supplement a vessel's over-the-horizon surveillance and intelligence capabilities. As such, it has been trialed in HMCS *Harry DeWolf*, the first of the RCN's new Arctic and Offshore Patrol Vessels. There are, moreover, plans underway for the inclusion of other UAV systems into the RCN's fleet. Through the uncrewed system program, led by the Director of Naval Requirements, the RCN is currently seeking to procure a family of systems able to be operated from all naval warships, to offer near real-time intelligence, surveillance, target acquisition, and reconnaissance (ISTAR) data.[191] The Navy entered into a contract in 2018 with the company Qinetiq to acquire an ISTAR UAV capability based on a Skeldar platform. This project was in the Definition stage in 2021, with the plan being to procure a remotely piloted tactical aircraft system for the Halifax-class vessels. A Request for Proposals was issued for such a system in August 2022, with a March 31, 2023, closing date. Evidently, there is considerable interest in the RCN in broadening its UAV capabilities.

In addition to such UAVs, the RCN has also been steadily integrating uncrewed surface vessels (USVs) and uncrewed underwater vessels (UUVs) into its fleet. Though their operation requires caution to coordinate and deconflict such surface and subsurface uncrewed vessels with other military and civilian vessels on or in the water, the benefits of such uncrewed systems for a naval fleet are clear. The Hammerhead uncrewed target system, for instance, is a Canadian-made USV that has long been in use by the RCN to practise defending against an attack. Capable of high speeds, and equivalent in size to a small motorboat, the Hammerhead is particularly notable for its value in training naval personnel to react to rapidly moving attack craft and – when multiple Hammerheads are deployed in a swarm – to respond to a coordinated assault involving several vessels. This training is especially relevant given the proclivity in contemporary maritime warfare to deploy similarly small and fast craft, brimming with explosives, in attacks on vessels. Vessels such as these have been used to great effect by the Ukrainians, for instance.

Furthermore, the RCN is also actively examining the potential to employ USVs and UUVs in high-risk and high-danger undertakings like minehunting. USVs capable of detecting and disarming sea mines already exist, and today's UUVs can conduct mapping, surveillance, and even anti-submarine warfare by detecting and confronting subsurface threats. In 2018, the Department of

National Defence (DND) launched the Remote Minehunting and Disposal System (RMDS) project, aiming to equip the RCN with the systems needed to perform diverse naval minehunting operations and enhance underwater domain awareness.[192] Utilizing a combination of government- and commercial-developed technologies to identify, detect, and eliminate underwater explosive devices and sea mines, the RMDS systems will be comprised of modular sub-systems that are both deployable and portable.[193]

Moreover, the RCN is similarly according increasing attention to the development and incorporation of uncrewed underwater vessels. For instance, in July 2022, representatives from the RCN, as well as from Australia, welcomed a demonstration from Cellula Robotics of its Solus-LR hydrogen fuel cell–powered AUV, or autonomous underwater vessel, off the coast of British Columbia. During the demonstration, the vessel – whilst underway and submerged – autonomously launched a micro-AUV, thus illustrating the AUV's ability to launch its own AUV. The demonstration also featured the Solus-LR surfacing to convey a status message over satellite. Given the difficulties typically associated with underwater communications between an uncrewed vessel and a ship or shore facility, the vessel's clear ability to communicate established its prospective utility for the RCN in the development and enhancement of situational awareness. Indeed, the Solus-LR showed great promise in its ability to both collect and transmit data, testifying to its potential to allow for the compilation and communication of real-time, over-the-horizon information from a submerged UUV/AUV.

The aforementioned UAVs, USVs, and UUVs represent but a handful of the uncrewed systems currently either in use or in development by the RCN. The expanding advancement and utilization of these systems, however, will require the RCN, CAF, and Canada generally to contemplate – and indeed regulate – not only how and when such uncrewed systems will be utilized but also whether they will be armed and, in the event they are, who will assume responsibility for their control. Such questions surrounding the control and use of these systems will only become more pertinent as developments in and the incorporation of advanced data analytics and artificial intelligence make the systems increasingly more autonomous. Moreover, though the systems are uncrewed, their operation and maintenance still require human personnel, making it imperative for the RCN to train or recruit personnel with the expertise needed to ensure the systems' full and complete integration into the RCN's vessels and fleet. The importance of these considerations will only be amplified as the RCN joins the numerous other maritime forces around the world that are progressively turning to uncrewed systems as a capability enabler. Indeed, the RCN's adoption of uncrewed systems can only be expected to increase given their potential to facilitate a variety of RCN missions, including the surveillance of Canada's maritime approaches, the charting of its Arctic waters, and the Navy's – and nation's – adaptation to the ever-evolving suite of contemporary challenges and threats.

III. Operations

Canadian Naval Task Groups

The Royal Canadian Navy (RCN) has long prioritized its interoperability with its allies. However, in addition to operating together with its allies, vessels of the RCN also often work independently. When doing so, RCN vessels regularly deploy and operate in task groups. As *Leadmark 2050*, the RCN's strategic document, explains, a naval task group entails "a tactically self sufficient grouping of ships, aircraft and submarines whose sensors and weapons are integrated into a highly cohesive warfighting whole."[194]

Navies have long deployed in task groups, and the concept is now enshrined in Canadian, American, and North Atlantic Treaty Organization (NATO) naval doctrine. RCN strategic documents have, over the past several decades, emphasized the need for a naval force that can act autonomously and be self-sustained. Government defence policy has also long recognized the role of task groups in supporting such a force. The 1994 White Paper on Defence championed the idea that the RCN must have a naval task group on each of the nation's coasts, and Canada's 2017 defence policy, *Strong, Secure, Engaged* (*SSE*), classified the naval task group as the RCN's "core … operating concept."[195] In accordance with government policy, then, the RCN must maintain a highly ready naval task group "whose ultimate purpose is to provide Canada with an independent and sovereign ability to control events at sea."[196]

In Canada, a naval task group is comprised of several components, including warships, a support element, and a command-and-control element (which itself includes the commander of the task group or CTG). *SSE* stipulates that a naval task group be "[c]omposed of up to four surface combatants and a joint support ship, and supplemented where warranted by a submarine," thus ensuring "the full breadth of combat capability, force enablers, specialized teams, maritime helicopters, and remotely piloted systems."[197] Meanwhile, *Leadmark 2050* identifies that a naval task group will possess one Victoria-class submarine (depending upon the mission's needs), one support vessel, multiple CH-148 Cyclone maritime helicopters (distributed throughout the task group to ensure that aircraft can be consistently and simultaneously airborne if and when needed), and two or three Halifax-class frigates. These frigates will, in the future, be replaced in a Canadian naval task group with one River-class destroyer, carrying the task group commander and their staff.

Since the delivery of the River class is still several years away, its eventual command and control (C2) functions currently fall to the Halifax-class frigates, four of which have been modernized to receive a supplemented command package that enables them to serve as flagships.[198] Despite these guidelines, however, the particular vessels that participate in a task group depend upon the mission and operation. Any combination of submarines, frigates, Maritime Coastal Defence Vessels (MCDVs), Arctic and Offshore Patrol Vessels (AOPVs), maritime patrol aircraft (MPA), and helicopters could comprise a Canadian naval task group. As the RCN continues to procure new vessels under the National Shipbuilding Strategy, it will also integrate its new Joint Support Ships (JSSs) and Canadian Surface Combatants (CSCs) into its task groups.

Operating such task groups is advantageous for the RCN for a variety of reasons. First, task groups are inherently flexible, in their ability to combine naval units with varying capabilities in order to best address the assignment or mission at hand. As a result, the Navy as a whole can become more

cost-effective, because the use of task groups means that not all vessels require all capabilities. Moreover, the integration into a singular task group of diverse assets like aircraft, surface vessels, and subsurface vessels can allow for the accumulation of information that enables all members of the task group to "see what each of them sees individually, from the ocean depths to near space, and throughout the electromagnetic and acoustic spectrums."[199] As such, vessels' intelligence-gathering and surveillance abilities are significantly enhanced, allowing for a fuller operating picture or recognized maritime picture. Furthermore, since a task group is self-contained, in that its components can fulfill all the functions required to maintain its operationality, it is able to defend itself from threats[200] and does not, unlike an air force or army, require shore-based facilities to remain effective. This flexible and self-contained nature means that task groups can change as their missions evolve, with vessels being withdrawn or added as needed. For a medium-sized navy like the RCN, task groups can enhance the navy's ability to perform naval diplomacy and to deploy in mere days' notice. It is the RCN's policy to constantly maintain some vessels at high readiness, and task groups enable the Government of Canada to rapidly respond to crises.

Cognizant of these advantages, the RCN has relied on task groups to undertake numerous high-profile missions. For instance, in 1991, HMCS *Athabaskan*, HMCS *Terra Nova*, and HMCS *Protecteur*, accompanied by five helicopters, participated in Operation *Friction*, which saw the task group being deployed to the Persian Gulf to aid the United Nations–mandated mission to blockade Iraq following its invasion of Kuwait. In so doing, the Canadian vessels participated in the larger US-led task force tasked with removing Iraq's forces from the country. In 2005, similarly, HMCS *Athabaskan*, HMCS *Toronto*, HMCS *Ville de Quebec*, CCGS *Sir William Alexander*, a boat crew, and a dive team deployed as a task group in Operation *Unison*, joining the US-led task force responding to the devastation of Hurricane Katrina. Five years later, in 2010, an earthquake in Haiti prompted Canada to deploy a task group of HMCS *Athabaskan*, HMCS *Halifax*, helicopters, and the Disaster Assistance Response Team to join Joint Task Force Haiti. This joint task force also involved the participation of the Canadian Army, as well as representatives from non-governmental organizations and the Department of Foreign Affairs. That same year, Operation *Podium* included an RCN task group, in addition to Royal Canadian Air Force assets (alongside the North American Aerospace Defence Command or NORAD), as part of the Canadian Forces' contribution to the Integrated Security Unit. Led by the Royal Canadian Mounted Police, this unit aimed to ensure the security of the 2010 Vancouver Olympic and Paralympic Winter Games.

RCN task groups have conducted a host of missions, ranging from maritime interdiction, ship escort, and sea denial/sea control to the enforcement of sanctions, disaster relief, and the support of onshore forces. These missions have also regularly seen RCN personnel assuming command over international naval forces, with some instances even seeing Canadian task groups partaking in international task forces led by Canadian task force commanders, as occurred in the Gulf War in 1991 and in Middle Eastern operations following 9/11. Canadians also frequently assume leadership of NATO task forces.

The naval task group concept elicits some questions as the RCN looks towards the future. A primary question revolves around the need for a task group to be self-sustaining, self-sufficient, and self-replenishing at sea, with respect to its weapons, fuel, ability to conduct basic repairs, supplies (of spare parts, water, and food), and provision of health services to its personnel. Such

replenishment responsibilities fall to the task group's support ship. The RCN, however, retired its two supply ships (AORs) in the mid-2010s, leaving the Navy with a significant capability gap as it awaits the construction of its JSSs under the National Shipbuilding Strategy. MV *Asterix* has assumed these replenishment duties as an interim AOR until the JSSs are delivered. Still, that this converted container ship constitutes the RCN's only replenishment vessel is problematic given that Canada's defence strategy calls for the Navy to be able to field a task group on both the Atlantic and Pacific Coasts.

Further questions regarding the future of the naval task group arise due to evolutions in naval technologies and capabilities. It is yet unclear what impact changes in communication technologies will have on task groups, or what ramifications uncrewed subsurface and surface vessels – which can be small but deadly – will have. New technologies could render task groups susceptible to swarming tactics, which could compromise their effectiveness in hostile environments and situations. *Leadmark 2050,* for its part, indicates that the RCN is cognizant of such questions and changes, and it acknowledges that the Navy must be "agile and adaptable" to respond effectively.[201]

Further challenges to the task group concept may arise from the increasing tendency to conduct whole-of-government operations. As task groups are expanded to include more government departments, RCN ships may be required to embark other government personnel, and task groups may need to also include vessels from, say, the Canadian Coast Guard. As combined and joint operations involving other civilian agencies and military forces become increasingly more common, it is unclear how RCN task groups will be impacted or how they will accommodate such expansions in participating personnel. Indeed, the shift to whole-of-government operations will increase the number of personnel requiring accommodations on participating vessels (including, potentially, not only command/control personnel but also public relations and legal personnel, as well as representatives from non-governmental organizations and other government departments). This could prove complicated, as contemporary warships are increasingly constructed to minimize their crew sizes. Another question still open for discussion is whether task group commanders will need to be physically stationed with their task groups at all, as advancements in technology allow them to immediately communicate and perceive the common operating picture from ashore. As naval technologies evolve, what a naval task group looks like and how it functions will evolve too.

The RCN and Counter-Narcotics Operations[202]

In addition to its combat role and its responsibility for the defence of Canada's maritime approaches, the Royal Canadian Navy (RCN) has a host of other peacetime taskings and objectives unrelated to combat. Among these functions are the RCN's enduring efforts to address and reduce the import of illegal narcotics into Canada and North America. Drug trafficking is an ever-increasing concern both nationally and internationally, due to its detrimental impacts on public health and its ability to fund the operations of terrorist, gang, and other criminal organizations. Though the responsibility for tackling this issue falls to civilian law enforcement agencies, navies like the RCN provide critical support in the struggle against illicit drug trafficking.

The RCN's efforts have led it to partake in counter-narcotic operations around the globe, oftentimes in collaboration with international partners, especially the US Coast Guard (USCG) and US Navy (USN). This cooperation, particularly with the USCG, is necessary because the RCN lacks a law enforcement mandate. Though international law provides for the Right of Visit in international waters, whereby a ship can be boarded if it is reasonably suspected to have partaken in an illegal activity like drug trafficking,[203] the RCN itself does not have legal authority to place individuals under arrest. Consequently, Canada and the US signed a memorandum of understanding in 2010 permitting USCG detachments to travel aboard Canadian warships to perform arrests.[204] As such, if USCG officials locate narcotics aboard a vessel, those narcotics are transferred to the RCN warship and thereafter to USCG vessels, with US officials arresting the traffickers under American law. This arrangement has proven to be effective.[205]

A key theatre for counter-narcotic operations for the RCN is the eastern Pacific Ocean and Caribbean. There, the RCN regularly participates in Operation *Caribbe*, deploying its destroyers, frigates, and Kingston-class Maritime Coastal Defence Vessels to intercept and impede the movement of illicit drugs, particularly cocaine, from South America to the US and potentially onwards to Canada. This operation is the Canadian component of the US-led Operation *Martillo*, a counter-narcotics operation that commenced in the 1980s in response to the inflow of cocaine shipments into Florida.[206] Now, responsibility for the operation falls to Joint Interagency Task Force South, a multi-national but US-based organization that seeks to "target, detect and monitor illicit drug trafficking in the air and maritime domains, within the Joint Operating Area (JOA)."[207] For the RCN, participation in this operation is primarily aimed at supporting the US's interdiction and surveillance efforts, which it does by operating warships as platforms for US civilian law enforcement personnel, as well as locating and tracking suspicious vessels for the USCG officials to board and investigate. Having participated in this operation since 2006, Canadians have contributed to the interception of an approximate 102 tonnes of cocaine and over 7 tonnes of marijuana through their participation in Operation *Caribbe* and Operation *Martillo*.[208]

In addition to the eastern Pacific Ocean and Caribbean Sea, the RCN's participation in counter-narcotics operations has also increasingly seen it deploying to the Middle East. Here, Operation *Artemis*, now involving a partnership of 33 nations, seeks to counter the illicit drug trade that funds terrorist organizations and their activities by securing regional waters like the Red Sea, Arabian Sea, Gulf of Aden, and Gulf of Oman. One element of this operation has vessels of the RCN participating in Combined Task Force 150 (CTF 150), which is the unit tasked with counter-terrorism operations and that collaborates with regional states to maintain the stability, security,

and safety of the Indian Ocean and adjacent maritime areas. The Task Force has, over the years, captured and disposed of thousands of kilograms of illicit substances.[209] Canada's participation in this counter-narcotic operation in the Middle East has seen it assuming operational control of the coalition on numerous occasions since 2008.

The third and final key region in which Canada and its navy partake in counter-narcotic operations is West Africa. While deployed to the region as part of Operation *Projection*, commenced in 2018 as a Canadian operation to elevate Canada's international relations and enhance international security, the RCN partakes in the multinational but US Navy–organized and –led Operation *Obangame Express*. Aiming to promote security and safety in the Gulf of Guinea along Africa's western coast, Canada's involvement in this operation focuses more on conducting training operations to enhance the regional maritime security forces responsible for counter-narcotic interventions than directly participating in those interventions itself. As such, the RCN collaborates with Canada's African partners to perform interdiction exercises centring on boarding, search, and seizure techniques.[210]

Inevitably, the global COVID-19 pandemic temporarily interrupted and hindered Canada's participation in these international counter-narcotic operations. While the RCN's deployment for Operation *Artemis* in 2020 concluded before the pandemic expanded and gripped the world,[211] Canadian naval vessels that had deployed to participate in that year's Operation *Caribbe* and Operation *Projection West Africa* returned home early, well before the operations had concluded.[212] Though the US announced in April 2020 that it intended to enhance its patrols of the Caribbean region, Canadian vessels did not participate in those counter-narcotics operations over the ensuing summer months. Fortunately, these interruptions were only temporary. The RCN resumed its counter-narcotic activities on October 26, 2020, when HMCS *Summerside* sailed from Halifax to partake in a two-month mission as part of Operation *Caribbe*. Since then, the Navy has continued to participate in counter-narcotics operations in the eastern Pacific Ocean, Caribbean Sea, Middle East, and West Africa, directly contributing to and supporting international efforts to ebb the tide of illegal substances into Canada and throughout the world.

Humanitarian Assistance and Disaster Relief Operations

In addition to their warfighting and constabulary roles, contemporary navies perform a variety of safety and support functions, including humanitarian assistance and disaster relief (HADR) operations.

Often, the first element of a country's response to an international disaster or humanitarian incident is maritime. Maritime forces are notable for their flexibility, mobility, interoperability, readiness, sustainability, and capacity to deliver large quantities of supplies, all of which make naval forces an exceptional asset to deploy in a HADR response. For instance, the Royal Canadian Navy (RCN) always maintains a number of vessels at high readiness to enable rapid responses to any situation. Though a naval response can be slower to arrive than an airlift, there are several critical advantages to employing naval vessels and task forces in response to HADR incidents. For instance, a naval ship has a significantly greater capacity than even a large airplane, enabling it to carry many tons of supplies and materiel. In Canada, naval vessels also have the capacity to house and support personnel and equipment of the Disaster Assistance Response Teams (DARTs) of the Canadian Forces, which can be rapidly installed on or assisted by RCN vessels.

Those vessels' capacity also allows them to serve as effective and efficient platforms by which to evacuate Canadians working or living in regions seized by conflict or a humanitarian crisis. Moreover, naval responses are not restricted or hindered by congestion in or damage to regional airports. Indeed, they are capable of launching small boats and helicopters, which are able to land onshore even if adequate port facilities are unavailable or damaged. Nor do the vessels demand the support of resources at the location of the disaster. Equipped to produce their own water, house and feed their own personnel, and transport and evacuate personnel through their own helicopters and boats, naval vessels are almost entirely self-sufficient. Critically, they do not place further strain on local infrastructure that is already coping with the aftermath of a disaster.

Naval fleets often have specific assets and capabilities that are particularly useful in HADR missions. The US Navy, for instance, boasts two hospital ships, USNS *Comfort* and USNS *Mercy*. Each containing up to 12 operating rooms, with a capacity of up to 1,000 patients, one hospital ship is stationed on the US's West Coast and the other on the East Coast. Both can deploy at five days' notice and regularly partake in humanitarian operations, typically in locations with limited or non-existent dental and medical facilities. There, their provision of free health services contributes significantly to naval diplomacy.

The RCN's replenishment vessels have also, historically, fulfilled a key role in the fleet's HADR responses. For instance, HMCS *Protecteur* participated in a HADR mission in East Timor in 1999, while HMCS *Preserver* deployed to Somalia as part of Operation *Deliverance* in 1992. While the RCN has since retired both vessels, MV *Asterix* is filling the fleet's capability gap on an interim basis, continuing the RCN's ability to transport vast quantities of disaster relief stores and cargo. The two Joint Support Ships that the National Shipbuilding Strategy will deliver to the RCN will further enhance the fleet's ability to respond rapidly and effectively to HADR needs.

With these capabilities, and in line with Canada's humanitarian image on the world stage, the RCN has participated in numerous HADR deployments in recent decades. For instance, it deployed to

Florida and the Bahamas in the fall of 1992 to aid relief efforts following Hurricane Andrew, and its vessels dispatched to support the US Gulf Coast after it was ravaged by Hurricane Katrina in 2005. More recently, the RCN participated in Operation *Hestia* in 2010 in response to the 7.3-magnitude earthquake that claimed thousands of lives in Haiti and caused serious and widespread damage. Within 48 hours of the earthquake, and under 27 hours after receiving the Warning Order, a task group composed of HMCS *Athabaskan* (with a helicopter detachment) and HMCS *Halifax* departed Halifax. They were equipped with hundreds of tons of disaster relief and humanitarian equipment and supplies, as well as around 500 soldiers, sailors, and aircrew. The US Navy's USS *Carl Vinson* also set sail from Norfolk, brimming with personnel, support stores, and helicopters. With its shorter distance to travel, it arrived in Port-au-Prince less than 72 hours following the earthquake. Thus, while the responding militaries and governments decided and planned the details of their responses, their relief was already en route. As the RCN vessels proceeded with their five-day trek to Haiti, their teams organized their efforts and prepared to exercise the host of non-traditional and traditional skills they estimated would be of use in the HADR response.

Upon their arrival, and as the HADR operation expanded in its scope and breadth, the ships and personnel of the RCN performed command and control of their naval humanitarian aid teams. By participating in technical support, general labour, force protection, and light engineering duties, they directly supported the disaster relief and humanitarian aid operation, in addition to providing medical aid, distributing or supporting the distribution of disaster relief and humanitarian supplies, and producing and delivering water. The vessels also offered support, transport, and lodging to the Canadian Forces and government personnel responding on the ground in Haiti. While damage to the airport facilities at Haiti's Port-au-Prince airport, and the airport's incapability to accommodate the number of large planes transporting material aid, produced congestion at the airport and hampered the delivery of airlifted aid, the responding naval forces did not encounter the same difficulties. Dispatching their small boats and helicopters, vessels sent their equipment and personnel teams ashore, where they contributed to security, distributed safe drinking water, constructed infrastructure like shelters and sanitation facilities, cleared roads, performed medical orderly services and medical triage, organized and distributed food, and supported the repair of crucial civilian and military equipment.[213] In collaboration with non-governmental organizations, and aided and directed by the Canadian Forces' DART, personnel from *Halifax* and *Athabaskan* thus delivered extensive and considerable aid.

Therefore, when countries like Haiti require disaster relief and humanitarian aid, much of the initial surge of aid comes via the sea. The RCN retains vessels at high levels of readiness to ensure its ability to quickly deploy to both perform and lead disaster relief and humanitarian assistance operations. While MV *Asterix* has supplemented the RCN's ability to transport disaster relief and humanitarian stores, the eventual delivery of the Joint Support Ships will further enhance the RCN's capability to provide ready, flexible, quick, competent, and useful HADR operational responses.

Marine Security Operations Centres (MSOCs)

For a maritime nation like Canada, boasting the world's longest coastline, establishing and maintaining maritime domain awareness is critical for national safety, security, and defence. Developing such an awareness – and thus being conscious of all the vessel, cargo, human, and related activities occurring on, in, under, or adjacent to the nation's oceans, seas, and navigable waterways – is vital to ensuring Canada's knowledge of and capacity to contend with any security and safety threats emerging from or in its maritime spaces. Today, Canada's Marine Security Operations Centres (MSOCs) are responsible for providing much of the nation's maritime domain awareness. Originating in the 2004 National Security Policy, which mandated their creation, the MSOCs are hubs that amass, analyze, and disseminate information regarding the maritime activity occurring off the nation's coasts. They do so through a suite of advanced technologies, including military-grade information fusion and tracking technology, as well as a long-range identification and tracking system. This system grants the Centres the ability to gather and store information from vessels operating on the high seas, by identifying and overseeing around 1,000 vessels daily from a distance of more than 2,000 nautical miles.

The MSOCs achieved full operational capability in early 2015, following the completion of key hardware and software upgrades and the signing of the MSOC Full Operational Capability (FOC) Certificate by the core MSOC partners. By that time, the data fusion centres had already been integrating marine intelligence for over two years. In January 2016, the FOC Certificate was endorsed by the Department of National Defence (DND) Project Senior Review Board and was thereafter signed by then–Commander of the Royal Canadian Navy (RCN) Vice-Admiral Mark Norman. This effectively transferred technical and operational authority over the project to the Navy, specifically to the Directorate of Naval Operations and Plans.[214] There are three MSOCs now in operation, monitoring the nation's most active and bustling maritime regions. One MSOC is housed in Canadian Forces Base (CFB) Halifax along the Atlantic Coast, CFB Esquimalt on Vancouver Island hosts the Pacific Coast's MSOC, and the third MSOC is situated in the Niagara region of Ontario, standing watch over the Great Lakes and St. Lawrence Seaway.

Individually, these Centres accumulate and analyze significant amounts of data from their marine environments to assemble a real-time image of the activities underway in the adjacent maritime domain. They are thus key in the rapid identification of threats – both immediate and prospective – to the nation's marine transportation system, subsequently sharing that information with partners and informing decisions on optimal responses.

Although the Atlantic and Pacific MSOCs are under DND's administration and direction, their "whole-of-government" staffing sees the Centres also hosting representatives from Transport Canada, Fisheries and Oceans Canada, the Royal Canadian Mounted Police (RCMP), and the Canada Border Services Agency (CBSA). The Centres thus rely on the utilization of inventive web-based tools to permit collaboration among participating departments and agencies. This multi-departmental approach facilitates cooperation, ensures that each department with a stake in Canada's maritime security and safety possesses an inclusive and real-time image of possible marine threats, and assures that the national response to those threats is effective, efficient, and avoids duplication. This collaboration also allows analysts at the Centres to select the best information from the pool of resources available to construct a thorough and complete appraisal

of the maritime threat and risks in question. The analysts can thereby suggest an appropriate response to the applicable chain of command, thus enhancing response effectiveness.[215]

On a day-to-day basis, the MSOCs monitor civilian marine activity and aid government partners with their regulatory mandates and civilian enforcement, including by tracking vessels suspected of participating in illegal migration, human smuggling, and drug trafficking. The relevance of such monitoring was aptly illustrated in October 2009, when 76 Tamil men from Sri Lanka arrived in British Columbia aboard MV *Ocean Lady*. Given the drastic measures that people take – and will continue to take – to seek better lives, as well as the drastic measures that others take to exploit such desperation for personal gain and profit, this case of illegal migration only highlighted the need for the maritime situational awareness and interdepartmental cooperation that the MSOCs facilitate.[216] Such illegal border crossings, smuggling, and organized crime are the focus of the CBSA and RCMP positioned at the MSOC facility at Niagara-on-the-Lake.[217] There, the RCMP, the lead agency at the Centre, works in conjunction with the US Coast Guard to police and monitor the inland waters – notably, the over 3,700-kilometre waterway (connecting over 50 ports) – of the Great Lakes and St. Lawrence Seaway.[218]

In addition to monitoring civilian marine activity and assisting in civilian enforcement, the MSOCs monitor the commercial marine industry as a crucial component of their daily tasking. Canada is a nation that conducts a significant share of its trade by ship. Annually, the marine industry handles 456 million tonnes of cargo – amounting to $117 billion in global trade – and itself produces $10 billion in national economic activity. This industry is responsible for the management and movement of around 97% of Canada's international trade with nations aside from the US, employing 100,000 Canadians in the process.[219] Ensuring the secure and safe passage and conduct of the vessels that thus conduct a substantial proportion of the nation's trade is a vital tasking that also falls to the MSOCs. They track cargo vessels entering and departing from Canadian ports, ensure abidance by Canadian regulations, and facilitate the orderly and smooth flow of commerce.

In Canada, marine activity also encompasses the nation's vibrant ocean economies, of which the fishing industry is a cornerstone. The MSOCs play a key role in monitoring the nation's fishing grounds, looking for illegal activity among the domestic and foreign fishing vessels. Although Fisheries and Oceans Canada is responsible for enforcement of this nature, the cooperation of other government departments is an integral enabling and supporting factor. As such, Canadian warships with fisheries officers onboard often engage in fisheries patrols, with the MSOCs assisting in the coordination and facilitation of these patrols through their provision of indispensable real-time information.

Occasionally, vessels operating off Canada's coasts encounter difficulties or require assistance. In these cases, too, the MSOCs are imperative. Responsibility for maritime search and rescue (SAR) falls under the purview of the Canadian Armed Forces, although other government departments like the Canadian Coast Guard can undertake maritime SAR responses if they possess the assets required to adequately respond. Coordinating these SAR efforts falls to the MSOCs, which ensure an effective response to maritime SAR incidents by providing critical information that enables personnel to focus less on searching and more on rescuing, even in times of poor weather or minimal light.[220] On the Atlantic Coast, MSOC East's close proximity to both the Regional Joint Operations Centre – which is mere steps away from the MSOC's watch floor – and Joint Rescue Coordination Centre has strategically facilitated such SAR responses.

While duties related to the monitoring and policing of Canada's maritime spaces comprise the majority of the MSOCs' present functions, the Centres' ability to provide and supplement a real-time situational awareness of activity off the nation's coasts is an important military and security consideration. Indeed, in addition to developing a picture of civilian and commercial activities in the nation's waters, the MSOCs' technologies and data-sharing capabilities can also monitor the activities of more nefarious actors and share that operational picture with allies. In such a situation, the MSOCs would be critical to supporting a military response and defending the country's maritime approaches.

Additional software improvements are planned for the watch floors of Canada's three MSOCs. These improvements will expedite the identification of anomalous behaviours at sea, like a vessel that suddenly halts its movement, or one that deviates from a planned route. Given the MSOCs' role in monitoring and policing domestic and foreign civilian, commercial, and economic activities, as well as in facilitating maritime SAR responses and providing a key conventional security capability, such upgrades to and renewals of the MSOCs' capabilities are important developments. The significance of their role in enhancing Canada's maritime domain awareness along the Atlantic and Pacific Coasts, as well as in the Great Lakes and St. Lawrence waterway system, makes the MSOCs a vital asset in the maintenance of maritime security and safety in Canada.

Ship-to-Shore Connectors

Ships remain the most efficient means to transport significant quantities of personnel, supplies, and equipment around the world. However, doing so also requires methods of transferring those items and personnel from the shore to the ship and vice versa. Indeed, vessels seeking to resupply, refuel, or unload or load material do not always have access to port facilities. If, for instance, local port facilities do not exist (such as in much of the Canadian Arctic), or if they have sustained damage due to a disaster or conflict, vessels must rely on alternate means to transport goods and personnel between the ship and shore, called ship-to-shore connectors.

There are a variety of means by which people, vehicles, heavy equipment, and stores can be transferred from ship to shore. In addition to floating pontoon platforms (called Mexeflotes, in the British tradition),[221] there are landing craft that can be launched with a crane off a ship's deck. Some warships can also deploy helicopters to transfer material and people to and from the shore. Other vessels with well decks (a segment of the vessel's lower part that can be intentionally flooded) can use the water to float landing craft on and off the vessel.

A Mexeflote is a system comprising three types of pontoons: a stern, centre, and bow.[222] Its modular construction allows for the pontoons to be joined in whatever arrangement or configuration – for instance, a jetty, powered raft, transfer platoon, etc. – best suits the mission, granting versatility and flexibility. Containing its own limited propulsion capabilities, a Mexeflote can operate independently, although its propulsion system is not designed or equipped for rough seas or extensive distances. Transportable by rail or road, the shallow drafts of the pontoons enable operation right to the shore. These Mexeflotes can thus be arranged to allow vehicles to drive directly onto the pontoons from a ship and thereafter onto shore. They can also transport containers that can be configured into, for instance, water processing/desalination units or medical units. Thus, during combat, in a post-combat situation, or in humanitarian assistance and disaster relief (HADR) operations, these Mexeflote pontoons provide an effective means to land personnel, supplies, and vehicles.

Notable uses of the Mexeflote include by the Knight-class vessels of the Royal Navy (RN), which transported two such pontoons outside the vessels to be configurated when and as needed. The Royal Fleet Auxiliary's Point-class vessels also carry Mexeflote pontoons on deck, with the ship's crane being used to lower the pontoons into the water, where they are then assembled into powered rafts. These rafts can transport up to 60 tonnes of supplies between the ship and shore in a singular trip. Such Mexeflote pontoons were an indispensable component of the RN's HADR response to the Haiti earthquake in 2010.

Another key ship-to-shore connector is the landing craft or small boats (zodiacs) that all warships carry. Launched over the side of the vessel via crane, and returned to the vessel in the same manner, these boats fulfill a variety of roles for warships. Some warships also carry helicopters, which can similarly undertake ship-to-shore connection duties. While both helicopters and boats can successfully transfer supplies, people, and equipment to and from the shore, the size and weight of material they are able to accommodate is restricted.

For bigger or heavier items, larger navies like the US Navy and RN have vessels in their fleets with roll-on/roll-off (RO-RO) capability – essentially, vessels that permit vehicles to drive into a large hold on the ship. Upon the vessel's arrival at its destination, the vehicles can thus simply drive off the ship, if there are sufficient port facilities, or otherwise use a pontoon system. In the RN, for example, this RO-RO capability comes from its Albion-class Landing Platform Dock. As amphibious warfare vessels, Albion-class ships can accommodate armoured personnel carriers, large trucks, and even tanks within their vehicle decks. The vessels possess eight landing craft to facilitate the disembarkation of vehicles and troops.[223] An Albion-class vessel can also carry four landing craft utility (LCU MK10) boats, each of which is large enough to transport vehicles as big as a tank and can be launched by flooding the vessel's well deck. In addition, the Albion class has four smaller landing craft, or LCVP (landing craft, vehicle, personnel) MK5, which are lowered into the water by crane and which can each transport two light trucks or 35 people.[224] The US Navy similarly has roll-on/roll-off capabilities. Its fleet boasts numerous ship-to-shore connectors, for differing purposes. For instance, the San Antonio–class amphibious assault force ships serve specifically to transport equipment, supplies, and personnel ashore.[225]

The Royal Canadian Navy (RCN) does not have vessels with RO-RO capabilities, onto which heavy equipment and vehicles can be driven. Its primary ship-to-shore connectors instead come from its helicopters and small landing craft, both of which were critical in the RCN's 2010 disaster relief operations in Haiti due to the destruction of the local port facilities and the tenuous onshore situation. However, the vessels that have been and that will be delivered to the RCN under the National Shipbuilding Strategy have their own ship-to-shore connector capabilities. The new Arctic and Offshore Patrol Vessels (AOPVs), for instance, each possess 12-metre landing crafts. Designed to transport equipment and personnel to shore in areas with limited or no available port facilities, the landing crafts are placed into the water and loaded with the ship's crane.[226] However, since each landing craft has a capacity of only four tonnes, they are not capable of transporting heavy shipping containers or equipment and are instead restricted to small vehicles (such as ATVs), cargo, and personnel.

The two large Joint Support Ships (JSSs) or Protecteur-class vessels contracted under the National Shipbuilding Strategy will provide the RCN with enhanced ship-to-shore connector capabilities. These ships carry ship-to-shore connectors similar to the Mexeflote, allowing the vessels to resupply and refuel warships at sea, which is their primary mission. The fall of 2021 saw the completion of an in-water Factory Acceptance Test for the first of the JSSs' four Sea-to-Shore Connector Systems. Comprised of modular pontoon barges that are assembled in the water and able to transport goods ranging from shipping containers to vehicles, the connectors will be capable of transporting 50 tonnes of cargo at five knots in sheltered harbours in which the ships cannot go alongside. The connectors moreover will possess beaching capabilities with ramps, allowing vehicles to be driven off the vessels. In granting the JSSs container-landing capabilities,[227] these connectors will elevate the ability of the JSSs – and the RCN – to conduct and support both HADR operations as well as onshore amphibious joint operations. Until these vessels are delivered, the RCN's at-sea replenishment support will remain with MV *Asterix*, an interim supply ship that was designed to fulfill the Navy's replenishment needs until the JSSs are commissioned. With two deck cranes and a container bay, and designed to carry Mexeflote pontoons, *Asterix* is Mexeflote-capable and regularly deploys helicopters and craft to transport supplies and people to and from the shore.

For modern navies, ship-to-shore connectors are indispensable assets. From the RCN's recurring use of Mexeflotes to deliver food, water, medical facilities, and building supplies in hurricane responses in the Caribbean, to the Royal Australian Navy's 2017 use during Exercise *Talisman Sabre* of a Mexeflote to transport a 57-tonne tank from HMAS *Choules* to shore, ship-to-shore connectors facilitate a wide range of operations and missions. Indeed, from conflict to HADR operations to rescue responses (for instance, like responding to a sinking cruise ship), ship-to-shore connector capabilities can expedite the evacuation of people and aid in the delivery of supplies and material. The RCN is in the process of enhancing its ship-to-shore connector capabilities and versatility with the commissioning of the AOPVs and JSSs, which will grant Canada's navy access to effective landing craft and Mexeflote technology.

Cyber Security and the RCN

As technology shifts and evolves, so, too, do warfare and weaponry. As much as technological developments have enhanced the efficiency of warmaking, they have also exposed it to new vulnerabilities. Specifically, just as the reliance of airlines, hospitals, businesses, and banks on computer systems has exposed such institutions to the risk of being hacked and breached, the ever-increasing computerization of navies means that those forces must confront a new potential avenue of threat and combat. Forces now contend not only with threats from the land, maritime, and air domains but also from the cyber domain.

A handful of definitions are required to inform this discussion. First, cyberspace entails information technology (IT) networks that are interdependent and that include, for instance, the internet, computer systems, telecommunication networks, and embedded controllers and microprocessors, in addition to the data and software they contain.[228] The cyber domain is comprised of all activities, users, entities, and infrastructure affecting or related to cyberspace, while a cyber threat "is an activity intended to compromise the security of an information system by altering the availability, integrity, or confidentiality of a system or the information it contains."[229] Finally, cyber security entails protecting data, software, hardware, and other systems connected to the internet from cyber threats. These are all concepts the Royal Canadian Navy (RCN) must consider as it constructs and procures new ships, and with which the Government of Canada must grapple as it seeks to integrate cyber warfare into the nation's defence policy.

The RCN, like the Canadian Armed Forces (CAF) more generally, has become increasingly reliant on the use of cyberspace for and in its operations. For instance, a modern warship has numerous computer networks, with command and control, communication (with other vessels, onshore facilities, aerial assets, and naval allies), propulsion, situational awareness, weapons, navigation, mechanical equipment, surveillance, and emergency response all relying on and utilizing computers. As such, networks "control the machinery that enables a ship to float and move, they ensure safe navigation, they control the weapons systems and maintain the recognized maritime and air picture for timely command and control."[230] Cyber networks are thus imperative for a naval fleet's operation, as well as its interoperability with allied fleets. They are also critical to onshore naval facilities and supporting naval infrastructure,[231] which similarly have become increasingly computerized.

There are, of course, significant advantages to this computerization of fleets and their onshore supporting units. Computers are not subject to fatigue or boredom, and they are capable of continually monitoring a variety of elements, including a vessel's surroundings, equipment, location, and air quality. By enabling more effective surveillance and monitoring, in addition to faster and easier data processing and the more efficient exchange of information, the integration of technology into warships enhances their productivity and efficiency. Technology can also reduce the physically demanding tasks a ship's personnel must perform and indeed even mean that the vessel requires fewer personnel to function. Given the complexity of contemporary warfare, computers are imperative to supporting and enhancing the operations of human personnel. Computers acquire and process a wealth of information from radar, uncrewed vessel, sonar, and tactical data networks, thus facilitating decision-making. Computers also assist in deploying and employing weapons. A human operator on their own, unassisted by technology, would be unable

to process the sheer volume of tactical information or adequately react, given the variety and speed of the available weapon systems.

However, this widespread reliance on technology and computers also exposes militaries to vulnerabilities. Computers can be hacked and breached, and thus a cyberattack could potentially "disable military networks that control the movement of troops, the path of jet fighters, the command and control of warships."[232] Naval fleets are not immune from this susceptibility, given how thoroughly naval systems now rely on computers. Traditionally, most cyber breaches in the naval sector were accidental or natural in character, stemming from, for instance, a power outage or a crewmember who mistakenly allowed access to a military computer by succumbing to a phishing attack or inserting a virus-bearing USB stick. More recently, however, breaches have become predominantly linked to deliberate actions by hostile or malicious actors. There are a variety of actors that may harbour an interest in disrupting naval systems and operations, ranging from states/state proxies to hacktivists, from criminal organizations to terrorists, all of whom are developing methods and means of exploiting system vulnerabilities.

Hostile state actors (for instance, state military and intelligence services) tend to be the most sophisticated, thanks to their possession of motivated personnel and dedicated resources. Cyber criminals, meanwhile, tend to be less sophisticated and, given their profit motive, less likely to target military forces.[233] Thrill-seekers, terrorist groups, and hacktivists often deploy available tools that do not need substantial technical skill, with typically little lasting effect on the targets beyond impacting their reputation. Insider threats, stemming from individuals within a military organization who permit access to a device, network, or system due to their desire for profit or on account of their discontentment with the organization, are more dangerous, since those individuals have access to internal networks and are inside the organization's security perimeter.

Given the breadth of naval systems that are now reliant on computers and technologies, a breach of any system could produce severe consequences. For instance, a cyberattack that targets a vessel's IT infrastructure, or a denial-of-service attack (an attack attempting to make a service or system unusable) on a weapon system, could imperil both the vessel and its crew. If a vessel's shipboard computers were taken out of use, the vessel's warfighting capability would be significantly diminished, endangering the crew and hindering the broader operation. Indeed, cyberattacks can be just as damaging as conventional attacks. For instance, recent years have seen hostile actors tampering with or "spoofing" vessels' communication and GPS systems. Given modern vessels' reliance on computers to position and locate themselves, this could result in groundings or collisions, causing significant physical damage.[234] Smaller, less conspicuous cyberattacks can be similarly damaging. For example, a corrupted database or network outage at a Fleet Maintenance Facility, while seemingly minor, could prohibit a vessel from sailing on an operation if it is unable to receive a key replacement part in time. Since computers are now integral to all aspects of naval operations, from the vessels' functioning to the control of their weapon systems and the operations of their onshore support infrastructure, there are a variety of avenues a hostile actor could take to disrupt naval operations.

Naval computer systems are now perhaps even more susceptible to cyberattacks given the commercial origins of many military technologies. While, historically, militaries often conducted their own research and development processes, militaries today predominantly rely on technology developed by private corporations, with many elements of their computer equipment being

purchased commercial-off-the-shelf (COTS). For instance, Canadian warships utilize a Microsoft operating system. As these COTS computer systems are incorporated into naval vessels, so, too, are those systems' cyber security flaws. Further security concerns may arise if hardware or software is produced internationally or by unfriendly actors, who may seek to exploit the system or capitalize on flaws to install malware. Ensuring the integrity of the supply chain is thus critical when procuring and constructing new vessels.

Cognizant of these vulnerabilities, the RCN has prioritized cyber security as an operational necessity. The RCN, like other modern navies, performs threat risk assessments and actively seeks to minimize its cyber-domain risks. Incorporating best industry practices and international state practices, the RCN has moreover established its own guidance for authorizing systems for use in its fleet, entailing the five central functions of Identify, Protect, Detect, Respond, and Recover. First and foremost, each design contract for new naval equipment includes cyber security considerations and requirements, and the RCN actively integrates cyber security architecture into its vessels' system designs to reduce risks. Mission-critical systems on vessels are required to have strict access control, regular data backups, strong respond and recovery procedures, multi-layer encryption, and continual network monitoring for any dubious abnormalities or anomalies. Firewalls, data encryption, multi-factor authentication, security education and awareness, firmware and software updates, comprehensive disaster recovery plans, domain separation, network monitoring, anti-virus toolsets, data backups, etc., are all cyber security controls that the RCN has implemented in its fleet. Frequent security patches and updates keep these systems guarded against emerging threats.

If an issue is detected, the RCN must respond to the damage caused as well as the actor that caused it. Oftentimes, identifying the source of a cyberattack is exceptionally difficult and time-intensive, but this attribution is imperative to be able to respond. A practical response to a cyberattack on a naval system thus entails identifying the problem, containing or restricting the damage, determining whether to initiate a secondary mode of operation, and returning the system to service as rapidly as possible. Responding to a cyberattack means segregating the system from external interfaces before rebooting in safe mode, relaunching applications, initiating secondary operation modes, etc. While cyber risks cannot be entirely eliminated, given the frequent and constant emergence of new threats, they can be minimized through such mitigation strategies.

Thus, while the computerization of naval equipment, systems, and networks has elevated their efficiency and productivity, it has also created new vulnerabilities. The naval systems of the RCN's fleet, aerial assets, and shore infrastructure are all susceptible to cyber threats, ranging from environmental disruptions and human error to intentional attacks, all of which can jeopardize naval operations and Canada's national interests. As such, the RCN has been incorporating cyber defence measures to protect its assets and personnel and reduce their risk of succumbing to cyber espionage and hostile cyber operations. Cyber security is now a major factor that the RCN must continually consider to protect its assets and operational capabilities.

The RCN in the Arctic

The Royal Canadian Navy (RCN) established a presence in the Arctic in the late 1940s, as the emerging Cold War with the Soviet Union raised the strategic value of the region and as the increasing American presence appeared to threaten Canada's national sovereignty.[235] This Canadian naval presence was sporadic and largely abandoned with the transfer of HMCS *Labrador* – the RCN's sole icebreaker – to the Department of Transport in 1957.[236] A renewed presence in the 1970s included semi-annual northern deployments (NORPLOYs), sparked by new fears surrounding sovereignty and growing concerns over Soviet submarine activity.[237] Historically, this presence has been defined by its sporadic nature, rising and falling with perceived need.

In the early 2000s, Canada broke with the tradition of sporadic attention and began regular Arctic deployments, with the long-term vision of establishing a sustainable and capable Arctic presence. In 2000, the RCN published *Leadmark: The Navy's Strategy for 2020*, outlining its strategy for the next two decades. The focus was naturally on the Atlantic and Pacific Oceans; however, the strategy highlighted the need to maintain a presence in the Arctic as well.[238] This was acted upon two years later when HMCS *Goose Bay* and HMCS *Summerside* sailed into the Canadian Arctic for the RCN's first northern deployment since 1989, kicking off the first of two *Narwhal*-series exercises. These combined exercises were followed by more elaborate deployments in 2005 (*Hudson Sentinel*) and 2006 (Operation *Lancaster*). In 2007, in the first iteration of Operation *Nanook*, HMCS *Corner Brook*, *Fredericton*, and *Summerside* travelled to the Eastern Arctic, beginning the annual Arctic training operations that continue today.

Most Canadian naval vessels are not designed for year-round operations in the Arctic and can only access the region during the short ice-free window from August to September. But over nearly two decades, the RCN has steadily improved its processes and equipment, slowly rebuilding the capabilities and corporate knowledge of the Arctic that were lost over the years. The most important lesson learned from these missions, however, is the difficulty of working in the North. The distances involved in Arctic operations and the lack of infrastructure in the region limit operations and mean that any exercises or operations there require careful advanced planning. Experience has shown that logistics and supply are the most daunting problems. The distance by sea from St. John's, Newfoundland, to Lancaster Sound between Devon Island and Baffin Island is 3,700 kilometres – roughly the distance from Nova Scotia to British Columbia – and there is little to support a ship once it arrives in the Arctic. Broken or missing parts, or unexpected necessities, have to be transported from thousands of kilometres away through limited shipping infrastructure. Fuel must be conserved en route and refuelling carefully planned.

Problems with communications and weather have also proven to have serious effects on operations.[239] Navigation in the Arctic has always been a tricky proposition, given the unreliability of the magnetic compass and poor accuracy of many hydrographic charts. Radio and satellite communication have, likewise, been unreliable, hindered by the Eastern Arctic's high mountains, ionospheric interference, and the geostationary orbits of most satellites. New technologies provide some solutions; for example, GPS has improved navigation, and satellite phones offer semi-reliable communication. Still, reliance on these technologies presents new problems as well. GPS systems can be off by a number of degrees in the Far North, internet and data transfer is slow, cell

service is often non-existent, and batteries are quickly depleted by the cold. For many of the problems of northern operations, there is (as yet) no obvious technical solution.

An answer to some of Canada's Arctic capability gaps has been new equipment and basing facilities. The Arctic and Offshore Patrol Vessels (AOPVs) provide the RCN with ships that have the ice-strengthened hulls needed to access more of the region for longer periods of time. The AOPVs are already increasing the RCN's presence and capability in the North. The first ship of the class, HMCS *Harry DeWolf*, was handed over to the Navy in July 2020, underwent RCN sea trials, and was commissioned into the Navy in June 2021. In winter 2021, *Harry DeWolf* made its first voyage to the North for cold weather and ice trials, apparently performing very well. The ship began its first major operation starting in August 2021. After participating in Operation *Nanook* 2021, the ship continued its four-month deployment by transiting through the Northwest Passage and then south along the West Coast, participating in Operation *Caribbe*, before travelling through the Panama Canal and back to Halifax. This is significant for RCN operations in the North – *Harry DeWolf* was the first RCN ship to go through the Northwest Passage since HMCS *Labrador* in 1954. Since that time, the RCN has taken delivery of roughly one new AOPV per year and will complete delivery of the fleet of six ships in 2025.

To alleviate some of the logistical and supply issues, the small port of Nanisivik is also being refurbished into a refuelling centre. The Nanisivik facility is based at a closed lead-zinc mine on Baffin Island. On August 10, 2007, then Prime Minister Stephen Harper announced its renovation as a means of refuelling government vessels in the North to expand their time in the region and operational radius. The choice of Nanisivik as a site was based on its location at the eastern entrance to the Northwest Passage, its preexisting infrastructure, the fact that it is relatively ice-free in the summer, and the location of a nearby airport at Arctic Bay. Construction delays typical of Arctic projects have slowed development and increased the budget, and the size of the facility has been reduced. Once in operation, the combination of the AOPVs and the Nanisivik facility will greatly expand Canada's capabilities in the region and relieve the RCN frigates and Kingston-class patrol ships of Arctic duties, for which they are ill-suited.

The AOPVs are designed to operate in the Arctic based upon a specific understanding of regional security requirements and likely future developments. While fears of circumpolar conflict and Russian remilitarization of the Arctic dominate media discussions of northern security, Canadian policy has consistently stated that conventional military threats are unlikely to emerge (although this may change following the Russian invasion of Ukraine in February 2022). Canadian policy has focused instead on the unconventional safety and security challenges created by increased shipping, resource development, and human activity in the Arctic. The RCN's Arctic training has, therefore, focused less on combat scenarios and more on oil spill responses, the interdiction of criminal activities, surveillance, and aid to civilian partners.[240] Many of the roles that will be played in the Arctic are not Navy responsibilities, and this means that the RCN will often play a support role. For instance, the RCN has no law enforcement mandate. Instead, it plays a support role to other government departments, such as the RCMP, Fisheries and Oceans Canada, and Environment Canada.

Future roles in the Arctic will be complex and evolving, driven as much by climate change and trends in global shipping and development as by federal policy. Despite this uncertainty and the

difficulties surrounding Arctic operations, the RCN has made considerable headway in building the assets and capabilities needed to extend its presence into Canada's ice-covered waters.

Crewing Naval Ships

Under the National Shipbuilding Strategy (NSS), the Canadian Coast Guard (CCG) and Royal Canadian Navy (RCN) are set to welcome a host of new vessels to recapitalize and renew their fleets. As such, the NSS has sparked significant discussion in policy circles and in the media, centring around such considerations as the vessels' capabilities, weapon systems, and communication technologies. An equally pertinent consideration – albeit one that receives less attention than the vessels' other assets – is how these vessels will be crewed. A ship's crew is a vital component of its operational effectiveness and efficiency, and constructing new vessels and new classes of vessels invoke new questions about crewing those ships.

Generally, naval warships require large crews. Given that the vessels undertake a variety of complex functions (ranging from diplomatic to constabulary, and defence to security), warships are inherently more complicated in their design than commercial vessels, which are tasked only with moving cargo. This more complicated design in turn demands a larger crew to ensure the fulfilment of its variety of roles. However, large crews produce large personnel costs. While reducing a vessel's crew would ostensibly lead to cost savings, too large of reductions can hinder the vessel's operations. For instance, as the US Navy observed from its Littoral Combat Ships, vessels designed to carry small crews can "present significant risks for manning and logistics (i.e., high workload and inadequate sleep for the crew, and inadequate shore support), and maintenance."[241] This could be a consideration for Canada's new Arctic and Offshore Patrol Vessels (AOPVs). Despite its large size, an AOPV can carry a maximum crew of 85 personnel.[242] While the vessels typically operate with a complement of 65 crewmembers, the RCN may increase their crew size if required for a certain mission or if a 65-person crew produces fatigue and thereby reduces the effectiveness of the vessel's operations.

The size of a vessel's crew is a decision that must be made early in the vessel's construction process, so that its design can take into account the extent of the eating/cooking, sleeping, and restroom facilities required to accommodate those personnel. While overestimating the crew's size can inflate design and construction costs beyond what were needed, underestimating the crew's size can reduce the platform's operational readiness or capabilities and later require expensive and time-consuming design changes.[243] Determining the optimal size of a crew is thus both imperative and difficult, especially for newly designed vessels or classes of vessels.

A vessel's technology is a key determining factor of the size of its crew – and what functions and tasks its crew will perform. Evolutions in technology, especially within the past century, have changed crews' responsibilities. For instance, the increasing automation of weapon and propulsion systems means that personnel are no longer required to manually load weapon systems or stoke coal for the ship's engine. Manual labour is now less integral to the operation of a warship than technical experience, and this prioritization of technical experience will only advance with further technological developments.

Increasingly, the technology on a vessel is becoming a determinant of the size of its crew, as well as the roles and qualifications required of that crew. As Renee Chow, Commander Ramona Burke, and Lieutenant-Commander Dennis Witzke note, "Once specific technologies are assumed, a specific number of roles can be defined for the crew to operate and/or maintain these technologies,

and the qualifications can be defined for each role."[244] By impacting both the crew's size as well as the types of people needed for the crew, the technology aboard a ship therefore also influences military occupational structures and the requisite training of its crewmembers. Indeed, shifts in the technology utilized aboard vessels require the addition of personnel educated in new trades, the elimination or combination of other trades, and adjustments to personnel classifications. Professions can hence appear or disappear with organizational and technological shifts.[245] Finally, the responsibilities that the ship itself is intended to fulfill also dictate the crew it must carry. For instance, a vessel tasked with conducting at-sea replenishment operations will require a crew for that, while a helicopter detachment is imperative for any vessel operating helicopters. Decisions on the personnel needed to staff a vessel, then, are largely contingent on the tasks it will accomplish and the technology it will equip.

The RCN's intention to increase the proportion of women serving in the Canadian navy is a further factor that is creating new complexities in matters of crewing. Since female crewmembers must be able to share accommodations with other female crewmembers, vessels must have adequate accommodation to support the women in its crew.[246] Vessel accommodations are adapting in kind. For instance, the modernization of accommodations in major warship designs has resulted in reductions to the number of personnel in each mess, providing more flexibility to ensure the adequate accommodation of any gender composition of crewmembers.[247] The modernization of the RCN's personnel composition is thus also requiring adjustments to vessels' accommodations facilities. So, too, are the international and Canadian regulations that govern the management and accommodation of crews. Indeed, regulations exist that determine the number of hours that personnel can remain on duty, their training, and their living conditions. Crew sizes and accommodations aboard vessels must necessarily take these into account.

It is possible that, as technology progresses, vessels will become autonomous and not require crews. Until then, human crewmembers are responsible for a variety of general and operational-specific tasks, including keeping watch, operating the propulsion systems, maintaining equipment and technology, cleaning, and food preparation, in addition to the fulfilment of the vessel's specific mission tasks. As a result, human crewmembers are still as integral to a vessel's operational effectiveness and efficiency as its propulsion or steering systems. Determining the size of such a crew when designing new vessels is a critical yet extraordinarily complex decision, involving the need to strike a delicate balance by determining the size of crew that is necessary for the vessel's optimal and effective functioning while minimizing personnel and accommodation costs. The technology aboard a vessel, the vessel's intended operational functions and missions, the need to accommodate female crewmembers, and a host of Canadian and international regulations all play further roles in determining the size of a vessel's crew, the qualifications it must possess, and the accommodations it requires. The crew that will operate a vessel is thus a key consideration during that vessel's design, and the design, construction, and delivery of vessels under the National Shipbuilding Strategy will inevitably take such matters of crewing into account. The continual progression of technology will continue to influence both the number of crewmembers required and the roles and responsibilities they must fulfill.

Naval Interoperability

Canada is a maritime state. Its economy is dependent upon its ability to trade internationally, and its foreign policy is outward facing and hinges upon international activity. As a middle power with a medium-sized navy, Canada has historically tended to participate in multilateral operations to maintain this level of international activity. Though in part by choice, a degree of this proclivity towards multilateral operations stems from necessity, in that the Canadian Armed Forces (CAF) broadly lacks the capacity required to achieve most international objectives by itself, without the aid of its allies. As such, Canada reconciles this restricted military capacity with its desire to be internationally active by exercising interoperability with its international allies.

Of the three services of the CAF – the Army, Air Force, and Navy – the Royal Canadian Navy (RCN) arguably enjoys the highest level of interoperability with its American counterpart. Since its founding in 1910, the RCN has worked alongside larger navies, initially with the Royal Navy and, since the Second World War, increasingly with the US Navy (USN). The continental military cooperation between Canada and the US dates back to the August 1940 Ogdensburg Declaration, through which the US president and Canadian prime minister established a Permanent Joint Board on Defence (PJBD) and laid the foundation for significant military cooperation between the North American neighbours. The 1941 Hyde Park Declaration strengthened this cooperation further, establishing that the US and Canada would coordinate and share their defence productions. The Canada–US military collaboration only deepened in the ensuing decades, with the standardization of their military technology, research, procedures, doctrine, and equipment, and perhaps most notably with the inauguration of the North American Air (now Aerospace) Defence Command (NORAD) in 1958. Though the term "interoperability" was not yet used, the stage for its practice was clearly set.

Indeed, the Cold War conduct of the North Atlantic Treaty Organization (NATO) demonstrated the growing trend towards interoperability. Confronting the Soviet threat and establishing collective defence required the NATO allies to operate together, which in turn required participating nations to adopt some standardization measures and ensure the compatibility of their military doctrines and equipment. Since the US military was – and remains – the largest actor in NATO, its navy was key in the development of NATO interoperability, and its technologies and capabilities remain the "standard" towards which other allied navies (including Canada's) have trended. Over time, a broadly accepted NATO maritime doctrine has emerged that offers guidance on how allied navies can and should operate collaboratively. Even when the Cold War drew to a close, NATO maintained its emphasis on its members' interoperability. Though the integration of new members into the alliance, starting in the 1990s, has presented challenges for that interoperability, years of joint exercises, training, and planning between NATO militaries have enhanced their ability to work together towards unified operational objectives.

In tandem with this evolving prioritization of interoperability through NORAD and NATO, the Canadian defence establishment has thoroughly adopted the concept. Canada's 2017 defence policy, *Strong, Secure, Engaged* (*SSE*), speaks of expanding the CAF's engagement with its like-minded and longstanding allies, including its fellow NATO members.[248] According to *SSE*, the Department of National Defence "will continue to demonstrate Canada's steadfast commitment to NATO by maintaining high-quality, interoperable, and expeditionary forces which Canada can

deploy, as needed, to effectively contribute to NATO deterrence posture, operations, exercises and capacity building activities."[249]

The term "interoperability" itself emerged in discourse in the 1990s, and it is sufficiently ambiguous to encompass a variety of interpretations and meanings. NATO's policies define it as "the ability for Allies to act together coherently, effectively and efficiently to achieve tactical, operational and strategic objectives,"[250] specifically noting that interoperability

> … enables forces, units and/or systems to operate together and allows them to share common doctrine and procedures, each other's infrastructure and bases, and to be able to communicate. Interoperability reduces duplication, enables pooling of resources, and produces synergies among all Allies, and whenever possible with partner countries.[251]

Interoperability does not require or suggest that states possess the same military equipment. Instead, it represents the ability of military forces to communicate, connect, interact, and exchange services and data with other naval allies and NATO members.

Various degrees of interoperability exist. Technical interoperability, for instance, refers to systems, armaments, equipment, and hardware, and it includes the ability of submarines, planes, and vessels to exchange information, including through satellite connectivity and digital exchange. Procedural interoperability entails similar or common procedures and doctrines, while human interoperability refers to similar or common training and terminology. More broadly, operational interoperability aims for units from different nations to be able to operate together in the pursuit of a common mission, while naval interoperability indicates that a multinational force of naval units can conduct missions towards a common operational objective as if it were a single, unified, national force. Naval interoperability in particular supplements the capabilities of the individual state forces involved. By involving a number of partner or allied navies working together, rather than one navy on its own, the total force's capability is elevated, enhancing its deterrent effect. Recurring exercises and training, as well as possessing common communication methods and protocols, are integral to maintaining this interoperability and ensuring that the forces are prepared to respond to any crisis that may occur.

The RCN has placed a great deal of focus on both the development and maintenance of command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) systems, as well as weapon systems, that are interoperable with those utilized by the USN. As a result of this interoperability, RCN units have occasionally assumed leading roles in US-led multinational coalitions. For instance, in the Gulf War, the high interoperability and compatibility of Canadian vessels with those of the USN led to the Canadian Task Group commander becoming the only warfare commander who was not American. This high level of interoperability has also allowed Canada's Halifax-class patrol frigates – thanks to their integrated combat systems – to be incorporated into American carrier battle groups.

There are real benefits to this policy of naval interoperability. Some commentators insist that it enhances the international effectiveness of the RCN, with Joel Sokolsky arguing that "[i]nteroperability with the US is the logical defence posture for a Canadian national security

policy based upon continued global engagement."[252] *SSE*, similarly, insists that "[s]trong partnerships with allies, partners and regional and international organizations are critical to the effective execution of the defence mandate."[253] As it continues, "Canada and the United States share an unparalleled defence relationship forged by shared geography, common values and interests, deep historical connections and our highly integrated economies. This relationship is critical to every aspect of Canada's defence interests and economic prosperity."[254] Thus, the RCN's interoperability with the USN arguably augments its ability to successfully perform foreign policy missions.

A further benefit of this RCN–USN interoperability is that it grants Canada influence on operations, providing it "a seat at the table," giving it access to information about the operations, and increasing its influence. According to Dan Middlemiss and Denis Stairs, "opting out of the partnership altogether is almost a sure-fire guarantee that Canada's interests will be benignly neglected or even deliberately ignored by the United States."[255] Finally, Canada, as a middle power, lacks the resources to expand its navy to the size needed to "go it alone," making interoperability a necessity for the nation to preserve the international profile it seeks.

Of course, this interoperability is not without its prospective drawbacks. Some people argue that integrating Canada so closely with the US curtails and diminishes Canada's sovereignty, with high military and naval interoperability restricting the Canadian government's ability to independently determine when, where, and how to partake in naval operations and activities. Instead, these decisions would be made in Washington, perhaps with little or no Canadian input. As Sokolsky notes, while interoperability may elevate the RCN's ability to usefully contribute in the maritime arena, "it is not likely to permit Ottawa a greater voice or leverage in Washington."[256]

Sokolsky aptly summed Canada's situation when he wrote that "[m]uch of Canadian foreign and defence policy since the founding of the country has involved navigating between the commitments and constraints that go along with being a global actor but not a global power."[257] Indeed, Canada faces two alternatives respecting its naval interoperability: embrace interoperability to broaden its international influence at the potential cost of its sovereignty, or turn away from interoperability at the expense of its international profile. For their part, the Government of Canada and RCN appear poised to continue to strengthen the nation's naval interoperability. The River-class destroyers, now under construction, are being planned with interoperability in mind, and the RCN continues to closely collaborate and cooperate with the USN and Canada's other naval allies.

Alliances, Coalitions, and the RCN

Canadian defence policy and its global posture has long centred on cooperation with like-minded states. Since the end of the Second World War, its commitment to the North Atlantic Treaty Organization (NATO) has been at the heart of this policy. In North America, Canada's defence partnership with the US has also led to its participation in the North American Air (later Aerospace) Defence Command (NORAD), a binational command focusing on the defence of North America. Both of these organizations call upon the Royal Canadian Navy (RCN) to work in close collaboration with allied navies and practise interoperability.

NATO was born in 1949 as the Cold War developed between the West and the Soviet bloc. Canada was one of the original 12 signatories of the North Atlantic Treaty, also known as the Washington Treaty. Now, 32 countries are members of NATO, and the alliance remains a central component of Canada's global defence policy. At the core of the alliance is Article 5 of the NATO Treaty, which summarizes the concept of collective defence that is the basis of the alliance:

> **Article 5**
>
> The Parties agree that an armed attack against one or more of them in Europe or North America shall be considered an attack against them all and consequently they agree that, if such an armed attack occurs, each of them, in exercise of the right of individual or collective self-defence recognised by Article 51 of the Charter of the United Nations, will assist the Party or Parties so attacked by taking forthwith, individually and in concert with the other Parties, such action as it deems necessary, including the use of armed force, to restore and maintain the security of the North Atlantic area.

As a result of this provision for collective defence, members of NATO are required to maintain a capability to both defend themselves and contribute to the defence of fellow member states. As Article 3 outlines, "In order more effectively to achieve the objectives of this Treaty, the Parties, separately and jointly, by means of continuous and effective self-help and mutual aid, will maintain and develop their individual and collective capacity to resist armed attack."

The RCN has long assumed a role in NATO's maritime forces. Northwood, Britain, holds the headquarters of Allied Maritime Command (HQ MARCOM), and there are numerous maritime components in the alliance. Indeed, in addition to the NATO Shipping Centre, there are two MARCOM Subordinate Commands (NATO Maritime Air Command (COMMARAIR) and NATO Submarine Command (COMSUBNATO)), as well as four Standing NATO Maritime Groups (Standing NATO Maritime Group 1 (SNMG1), Standing NATO Maritime Group 2 (SNMG2), Standing NATO Mine Countermeasures Group 1 (SNMCMG1), and Standing NATO Mine Countermeasures Group 2 (SNMCMG2)). These four Standing NATO Maritime Groups or Standing Naval Forces (SNFs) ensure that NATO maintains a constant naval presence and capability, and together they constitute the central component of the alliance's Very High Readiness Joint Task Force (Maritime). In addition to deterring hostile activities or attacks in the North Atlantic, they are also intended to maintain freedom of navigation and freedom of the seas in international waters.

Initially called Standing Naval Force Atlantic (STANAVFORLANT) until 2005, SNMG1 is a multinational force aiming to deter hostilities in the North Atlantic. Usually comprising between four and six frigates and destroyers, it offers an instantaneous response capability, which it hones through training exercises, interactions with member navies, and operational deployments that seek to retain high interoperability, readiness, and warfighting abilities. Vessels of the RCN are recurring participants in this force. Indeed, its frigates participate on a rotational basis, engaging in operational taskings and exercises in the NATO Maritime Command's areas of responsibility. For instance, RCN frigates are regularly deployed as part of Operation *Reassurance*, NATO's regional deterrence and assurance operation, and have served as flagships for SNMG1's command team.

Meanwhile, SNMG2, initially called Standing Naval Force Mediterranean (STANAVFORMED) until 2005, focuses on operations in the Mediterranean (although it also deploys farther south). It, too, is typically composed of between four and six destroyers and frigates. In that theatre of operations, SNMG2 has supported NATO's efforts to halt the movement of terrorists as well as their narcotics and weapons. Other notable deployments include Operation *Allied Protecteur* in 2009, which sought to defend vessels of the World Food Program against pirates off Somalia, as well as Operation *Ocean Shield* starting in 2009, which was an anti-piracy operation in the Gulf of Aden. NATO's remaining two standing naval forces (SNMCMG1 and SNMCMG2) are immediate reaction groups focusing on mine countermeasures. While SNMCMG1 operates in the Atlantic, SNMCMG2 operates in the Mediterranean. NATO moreover has COMSUBNATO, a dedicated submarine command that is responsible for all submarines assigned in support of NATO exercises and operations, including those from NATO member states and non-NATO partner states.

The second formal defence arrangement in which Canada is a member is NORAD. Formed in 1958 in the midst of the Cold War in response to concerns that Soviet bombers and missiles could strike the North American continent, the Canada–US binational command predominantly focuses on the space and air arenas. While it did not historically include the maritime approaches to the continent, changes to the agreement in 2006 expanded NORAD's mission to include maritime warning. Since its mission in the maritime arena is warning, not control, control and surveillance remain the responsibility of the individual national commands and are only bilaterally coordinated if absolutely necessary. As such, NORAD's current maritime mission entails gathering, processing, evaluating, and disseminating information regarding the maritime areas of the US and Canada, to enable the national agencies tasked with maritime defence to identify threats and the appropriate responses to them.

NATO and NORAD comprise the only two formal defence alliances (or arrangements) in which Canada is a member. However, Canada has been internationally active in other defence or security operations unrelated to formal alliances. For instance, the United Nations (UN) has, since its post–Second World War formation, been central to Canada's foreign policy. While the UN is premised on the concept of collective security, and is not a formal defence alliance, the UN Security Council (SC) has frequently passed decisions that have resulted in Canadian Armed Forces participation and missions. Some of these missions have involved maritime forces. For instance, Canada participated in the UN-authorized force tasked with removing Iraqi forces following their 1990 invasion of Kuwait. HMCS *Terra Nova* and HMCS *Athabaskan* similarly participated in Operation

Friction during the Gulf War to aid in the enforcement of the UN's trade blockade against Iraq, during which the HMCS *Protecteur* supply vessel provided at-sea medical services, command/control, and underway replenishment. There have also been several instances of NATO forces undertaking UN-authorized missions. For example, STANAVFORMED (now SNMG2) engaged in patrols off the former Yugoslavia in the 1990s in support of a UN SC resolution to prevent the transportation of weapons to the conflict in Bosnia, with Canada contributing three vessels to the so-called Operation *Maritime Guard*. Following 9/11, the UN's authorization of naval, air, and land operations against Afghanistan led Canada to contribute five vessels (as well as ground and air forces) to Operation *Apollo* to counter terrorism in the Persian Gulf. Then, in 2011, vessels from NATO SNMG2 and SNMCMG2, accompanied by other maritime air and naval assets from NATO members, participated in Operation *Unified Protector*. That deployment was part of a UN SC–authorized operation to support the Libyan population during the Libyan Civil War by curbing the transport of weapons into the country. The RCN's participation in UN-authorized naval missions has endured. Canadian frigates and maritime patrol aircraft, as well as a submarine and the MV *Asterix* supply vessel, have engaged in Operation *Neon*, enforcing the UN's sanctions against North Korea.

The RCN has also undertaken international naval operations as part of "coalitions of the willing." Specifically, the RCN has regularly participated in Combined Maritime Forces (CMF) operations. Headquartered in Bahrain, CMF is a voluntary partnership founded by the US following 9/11 that conducts maritime counter-terrorism operations as part of Operation *Enduring Freedom*. Composed of three multinational task forces with distinct focuses and mandates (namely, CTF 150, focused on counter-smuggling and counter-terrorism operations; CTF 151, with a counter-piracy mandate; and CTF 152, concentrating on maritime security), the CMF has progressively grown to also include broader threats to maritime security. CTF 150 specifically has welcomed the involvement of numerous nations, including Canada, Australia, Denmark, Germany, France, Italy, New Zealand, the Netherlands, Pakistan, Saudi Arabia, Spain, the US, and the UK. Covering the Gulf of Aden, Gulf of Oman, Indian Ocean, and Red Sea (excluding the Arabian Gulf, which is the jurisdiction of CTF 152), CTF 150 is thus responsible for a vast area of over two million square miles. Included in this extensive territory are integral shipping lanes and three choke points in which vessels are particularly vulnerable, namely the Bab el-Mandeb, the Strait of Hormuz, and the Suez Canal. Since 2012, Operation *Artemis* has been Canada's contribution to CTF 150, with Canada frequently assuming command under the task force's rotating system of command.

Though not in itself a defence alliance, Canada's participation in the Five Eyes is a further involvement utilizing military capabilities and assets. An intelligence alliance composed of the US, UK, Australia, New Zealand, and Canada, the Five Eyes seeks to gather intelligence from the five states and disseminate that intelligence within the group in order to develop mutual understanding of the threats stemming from non-state and state actors. This intelligence can include geospatial intelligence (analyzing data and images respecting a particular location), human intelligence (interpersonal contacts), defence intelligence (regarding the assets and capabilities of foreign militaries or hostile entities), and signals intelligence (such as the electronic systems and signals utilized by foreign targets, like their radars, weapon systems, and communication suites).

Given that most of the world's population is concentrated around its oceans and maritime spaces, it is inevitable that navies will continue to assume a critical role in addressing conflicts and crises in the future. Recent geostrategic tensions and international conflicts make it exceedingly likely

that the RCN will continue to deploy internationally in response to maritime crises and threats. It will thus continue to dispatch its vessels and personnel on behalf of the UN, NATO, and the Government of Canada, in addition to as a component of broader, multinational coalitions.

The Canadian Coast Guard and the RCN: Roles and Responsibilities

Canada's status as a maritime nation, bounded on three sides by oceans, heavily reliant on the seas for the conduct of international maritime trade, and home to the world's longest coastline, has led to its development and maintenance of two separate sea-going services. Both tasked, broadly speaking, with the protection of Canada's national interests, the Canadian Coast Guard (CCG) and Royal Canadian Navy (RCN) share several key roles and occasionally overlapping responsibilities. However, the CCG and RCN are independent organizations, operating separate fleets with varying capabilities for the fulfilment of operational mandates and responsibilities that are, at their core, distinct.

Formed in 1962, as a component of the Department of Fisheries and Oceans (DFO), the Canadian Coast Guard is a civilian service. Its operational mandate is extensive, encompassing fisheries patrols, environmental protection, navigational aid, support to law enforcement, maritime search and rescue, and icebreaking. It has a key function in the maintenance of Canada's maritime domain awareness, by monitoring maritime activity, managing vessel traffic, conducting vessel screening, and tracking vessel movements to identify potential security threats. It subsequently supplies this information and intelligence to Canada's Marine Security Operations Centres (MSOCs), thus providing valuable details to enable those Centres to develop a comprehensive image of vessel activity and movements in Canadian waters to inform the nation's security and maritime services. The CCG's role, as a steward of Canada's waters, also makes it the lead agency in any response to a pollution incident within those waters. Indeed, in addition to operating environmental response teams, the CCG also provides on-the-scene commanders to coordinate a pollution response. Alternatively, if the party responsible for the pollution is capable of responding itself, the CCG provides a monitoring officer.[258]

In addition to monitoring activity in Canada's maritime approaches and assuming leadership in pollution responses in those waters, the CCG also bears responsibility for ensuring safe navigation throughout the nation's navigable waterways. As such, it is entrusted with setting and maintaining aids to navigation, such as lighthouses and buoys, that promote and expedite safe operations in Canada's internal waters and along its coasts. It furthermore endeavours, alongside the Canadian Hydrographic Service (also a DFO agency), to expand the mapping of the nation's shipping lanes. This objective is especially crucial in the Arctic, where the CCG continues to chart waterways and expand safe shipping routes in the region. In the Canadian Arctic more broadly, the CCG serves as the most conspicuous representation of the Canadian state on the water, with its five medium and two heavy icebreakers showing the flag across the Northwest Passage during the navigable summer season.

Apart from these specific responsibilities, the CCG also operates in support of other federal departments and other DFO agencies in the fulfilment of their respective mandates. While it does not have the mandate to enforce Canadian law, given that it is not a law enforcement or military service (unlike many other international coast guards), the CCG offers critical support to agencies that *do* enforce Canada's laws. Its taskings regularly entail the CCG working alongside Canadian fisheries officers and the Royal Canadian Mounted Police (RCMP), serving as platforms for representatives of those agencies in their efforts to protect the nation's fisheries, enforce

regulations and laws in Canadian waters, and prevent and address trespassing. It also assists in the prevention of illegal fishing and the support of fisheries research, alongside other DFO agencies, in the nation's fishing grounds.

As such, the CCG serves a very different purpose from the RCN. While the CCG's primary concern is safety, the *raison d'être* of and paramount responsibility for the RCN is security and defence – namely, the defence and security of Canada's maritime approaches and, in collaboration with the United States, the defence and security of the maritime approaches to North America more broadly.[259] The RCN thus possesses a military character and nature that enables it to offer a degree of deterrence and defence that the CCG cannot. This core mandate also means that the RCN focuses its attention on hostile actors from other states, rather than trespassers or criminals (although it has recently embarked on counter-terrorism and counter-piracy operations). This mandate moreover brings with it an international role that the CCG does not possess. Indeed, because Canada's security hinges on an international alliance system, many of the RCN's taskings take it overseas.

The two maritime services are comprised of differing assets specifically attuned to their individual duties and obligations. While the CCG boasts a diverse fleet of science vessels, survey ships, icebreakers, buoy tenders, and multi-purpose vessels, suitable for and reflecting the diverse responsibilities of the civilian service, the combat vessels (like submarines and frigates) and patrol craft (for domestic operations) of the RCN testify to its military functions. These distinctions will continue to enable Canada's two maritime services to collaborate and coordinate on their shared national security objectives.

IV. Concepts

The Law of the Sea and Canadian Maritime Security

Peace, order, and good government were the founding principles of federal power in Canada,[260] and the country has grown prosperous through the application of these same rules to the world's oceans. The majority of global trade moves through the world's sea lanes, and, as a trading nation, Canada relies upon the sea to import goods from abroad and send its products to customers worldwide. Strategically, Canada and its allies have long relied upon the seas to project power, to connect North America and Europe in times of war and deploy forces abroad when necessary. As such, the peaceful management of the world's oceans within a stable, rules-based system of international governance has been a Canadian priority for generations.

Today, this framework is provided by the United Nations Convention on the Law of the Sea (UNCLOS). UNCLOS is one of the world's most comprehensive and effective international treaty systems. Signed in 1982 (and ratified by Canada in 2003), the treaty entered into force in 1994 and has now been ratified by 168 parties. A comprehensive system of maritime governance, UNCLOS sets the rules for the use of the world's oceans, codifying navigational and maritime research rights, environmental responsibilities, and the limits of states' fishing rights, territorial waters, and exclusive economic zones. Upholding this treaty, and defending Canadian rights defined by it, are important components of Canada's maritime policy.

Because Canada relies upon the world's oceans for both trade and defence, maintaining the freedom of the seas has long been a priority for the Royal Canadian Navy (RCN). Codified by UNCLOS, this freedom provides Canada with navigation and overflight rights through the "high seas," which constitute those parts of the oceans not included in the internal waters or the territorial seas of other states.[261] This free access provides Canada with the right to operate on, above, and below the surface of the high seas, providing global mobility and the ability to reinforce allies or project force anywhere in the world.[262] This area of manoeuvre is expansive, covering nearly half of the Earth's surface. Because Canada and its allies and partners possess most of the world's most powerful navies, this freedom skews heavily towards our strategic interest.

UNCLOS also provides access to warships and commercial vessels through the many choke points separating the world's oceans. These "international straits" are bodies of water that pass through a state's territorial sea, are commonly used for international navigation, and connect two parts of the high seas, or the high sea and a state's territorial sea.[263] These strategic, high-traffic locations – such as the Straits of Malacca and Hormuz – carry a disproportionate amount of global trade and vital commodities, such as oil. UNCLOS provides the legal framework that guarantees the right of transit passage to both state and commercial vessels through these straits, without which global commerce would suffer and Canadian and allied strategic mobility would be badly hampered.[264]

While deployed abroad, RCN vessels enjoy sovereign immunity, a provision within UNCLOS that essentially conveys diplomatic immunity to warships and other government vessels operating in foreign waters on non-commercial missions.[265] This legal protection exempts Canadian warships from local territorial jurisdiction while operating in a state's territorial waters or exclusive economic zone. As a blue-water fleet with extensive operations abroad, this provision is essential for Canada.[266]

UNCLOS also enshrines Canada's sovereign rights and responsibilities in its home waters, an immense region of roughly 7.1 million square kilometres of ocean space – roughly 70% the size of the country itself.[267] This makes Canada one of the largest coastal states in the world. It is also one of the richest in terms of the natural resources found in these waters.[268]

Canada's territorial waters stretch 12 nautical miles from its coast. Within these areas, it exercises full sovereignty, though foreign states enjoy the right of innocent passage.[269] Further out, Canada's jurisdiction over living and non-living resources extends to 200 nautical miles within its exclusive economic zone (EEZ). Technically, the EEZ is measured from the baselines running along the coast from which the country's territorial sea is measured.[270] Within this sizable area, Canada does not have sovereignty, but it does have certain rights, controlling fisheries and other living resources, as well as natural resources such as mineral, oil, and gas deposits.

In addition to its EEZ, Canada also claims jurisdiction over an extended continental shelf in the Atlantic and Arctic. UNCLOS allows a state to extend its jurisdiction over shelf resources beyond 200 nautical miles if it can show that its continental shelf is a natural prolongation, or continuation, of the state's land territory.

The Royal Canadian Navy, in cooperation with the Canadian Coast Guard and other government departments, ensures the security of Canada's sovereign waters and those over which it exercises jurisdiction. The maintenance of Canadian sovereignty and its economic interests require the ability to monitor these areas, police and regulate activity, and ensure that Canada's internationally recognized rights are respected.

Arctic Sovereignty

Canadian Arctic policy has long held that the waters of the Canadian Arctic Archipelago are historic, internal waters of Canada. As such, Canada enjoys the same sovereignty over these waters as over any other lake or internal body of water within the country. While national policy has supported foreign shipping through the channels of the Arctic Archipelago – commonly referred to as the Northwest Passage(s) – Canada reserves the right to regulate unilaterally any such activity.

The extent of Canadian sovereignty is defined by maritime closing lines called straight baselines. Straight baselines mean that instead of the lines following the coast in and out of bays/inlets, they are drawn straight across the coastline. The Canadian lines were drawn on January 1, 1986, by the government of Brian Mulroney after the voyage of the US Coast Guard icebreaker *Polar Sea* through Canadian Arctic waters. The voyage of *Polar Sea* caused consternation in Canada because it raised the specter of an American challenge of Canadian sovereignty, leading Canada to clarify its position in the North.

The establishment of straight baselines represented the first official delineation and definition of the extent of Canada's Arctic maritime sovereignty. However, this was not a claim to sovereignty *per se*. Since the Arctic waters have long been considered historic Canadian waters, the baselines only define the waters over which Canada has long exercised sovereignty. This sovereignty dates to the late 19th century, and it has been supported by a history of government activity exercising authority over the region through the issuance of fishing licences and the application of Canadian laws. It is buttressed as well by the presence and activity of the Inuit over thousands of years.[271] This position is succinctly summed up in the "Statement on Canada's Arctic Policy" in 2010, which notes that Canadian "sovereignty is long-standing, well-established and based on historic title, founded in part on the presence of Inuit and other indigenous peoples since time immemorial."[272]

The United States has never accepted Canada's claim that the waters of the Arctic Archipelago are historic internal waters, over which it enjoys complete control. This disagreement has persisted since the early 1950s and turned into a political confrontation in 1969, with the voyage of the US tanker *Manhattan* through the Northwest Passage, and again in 1985, with the voyage of USCGC *Polar Sea* through those same waters.

Historically, the United States has actually shown little interest in maintaining its access specifically to the Arctic waters. Rather, American interest has revolved around global freedom of navigation and the fear that acquiescence to Canada's claim might weaken the US position elsewhere. David Colson, a US State Department official negotiating with Canada in 1986, put it very simply: "we couldn't be seen doing something for our good friend and neighbor that we would not be prepared to do elsewhere in the world."[273] This fear of setting a precedent has dominated the American approach to the Arctic since the 1950s, and it continues to be represented in that country's Arctic policy statements.[274]

From a strictly legal perspective, the possibility of the Canadian Arctic setting a broader precedent has declined since the signing of the United Nations Convention on the Law of the Sea (UNCLOS) in 1982. This treaty codified rules for free transit through international straits and created a new

legal category for "archipelagic" states, such as Indonesia and the Philippines. In so doing, the Convention removed the possibility that other states could hold up Canada's position in order to close vital trade routes through their own archipelagos (which was a pressing US concern from the 1950s to 1980s).[275] Today, there are few straits around the world that might be considered comparable to the Northwest Passage and that would therefore be affected by any precedent set there.

However, one area that does closely compare is the straits of the Russian Arctic. This has long been an important American consideration. Accepting Canadian control over the Northwest Passage would indirectly buttress Russia's claim to the Kara, Sannikov, Dmitry Laptev, and Long Straits. During the Cold War, the USSR (Union of Soviet Socialist Republics) claimed many of these areas as internal, prompting an American Department of Defense official to state that, even if Canada's Arctic sovereignty claims could be substantiated in law, the risk of this precedent strengthening the Soviet claim required the United States to oppose the Canadian position. These strategic concerns remain to this day.

While the Americans recognize the validity of straight baselines in international law, Washington has asserted that these lines must be drawn in conformity with a more rigid interpretation of the relevant international law. When Canada drew straight baselines in 1985, the US government conveyed its belief that any such lines exceeding 24 miles (twice the territorial sea) could not be considered acceptable under international law. Canada's total baseline length in the Arctic is nearly 3,000 miles, with the largest enclosed section being McClure Strait, at roughly 130 miles across. Washington also feels that the Arctic Archipelago fails the geographic test laid down in UNCLOS III, namely that an archipelago must consist of a "fringe of islands along the coast in its immediate vicinity."[276] Essentially, Canada and the United States base their positions on Arctic sovereignty on the same precedents and conventions in law; however, they interpret that law differently. Because those relevant sections in the law of the sea leave much to interpretation, both sides can marshal evidence in support of their positions.

Rather than sovereign Canadian waters, the United States asserts that the Northwest Passage is an international strait – a body of water passing through a state's territorial sea, which is commonly used for international navigation and which connects two parts of the high seas, or the high sea and a state's territorial sea. Under existing conventional law, a right of innocent passage exists through such straits, and, should the Northwest Passage be defined as such, Canada's ability to regulate shipping, enforce its laws, and institute certain pollution prevention measures would be restricted. Prior to the 1970s, the United States avoided using this term, in large part, because Canada's three-mile territorial sea left a section of high seas in the centre of the Passage. After Canada's adoption of a 12-mile limit (legislated in 1970), the entrances and exits to the Passage were covered by territorial sea, and rights of transit came to rest on the Northwest Passage as a strait.

In an increasingly ice-free Arctic, Canada will have to manage more shipping and economic activity in the region. Effective control is therefore important. Exercising this control, while providing Canadian support for maritime activity in the region, not only demonstrates Canadian sovereignty but allows Canada to leverage its assets to encourage compliance. While the Canadian Coast Guard is the lead agency in the North, Canada is preparing naval enforcement capacity with

six Arctic and Offshore Patrol Vessels. It was recently announced that the Coast Guard will receive two somewhat modified versions of these vessels as well, so capability in the North will increase. The Department of National Defence's White Paper, *Strong, Secure, Engaged*, also offers promising commitments in situational awareness, while Defence Research and Development Canada is spending millions of dollars on new monitoring technology for the Arctic waters. Canada is responding to the potential for more maritime activity in the Arctic by both increased political attention and increased capability.

Pandemics and the Maritime Arena

The COVID-19 pandemic demonstrated the colossal toll that pandemics can take on every level of society, from the micro level of the individual to the macro level of international relations. Activities in the maritime arena were not immune from these effects. The decimation of the cruise industry, the severe interruptions in cargo and container shipments, and the impact on navies' crew health, operations, and future budgets all demonstrated the sweeping ramifications that pandemics can have for activities in the maritime arena.

The cruise industry's suffering commenced in the early stages of the global pandemic, when several extremely publicized COVID-19 cases aboard cruise vessels obliterated bookings and prompted waves of cancellations. Ports across the world, including in Canada, restricted access to cruise vessels, with Canada outright prohibiting the operations of cruise vessels in Canadian waters for over a year, until November 2021.[277] The impacts of such restrictions extended far beyond denying people the ability to enjoy international cruise travel. Indeed, the cruise industry employs hundreds of thousands of people internationally, as well as several thousand Canadians, ranging from the personnel crewing the vessels to their maintenance staffs and booking personnel. For these people, the interruptions to the cruise industry were financially disruptive and potentially devastating.

The economies of port communities that host cruise ships similarly suffered. Since cruise tourists infuse millions of dollars into port communities by visiting attractions, purchasing souvenirs, attending restaurants and bars, and spending money, the loss of this income deprived communities of key support for local businesses and local jobs. While the global cruise industry has had to contend with severe viruses like norovirus in the past, the coronavirus posed a particular challenge given its airborne nature and the consequent difficulty in controlling its spread, particularly in a confined setting like a ship. Moreover, COVID-19 tends to have disproportionately severe health impacts for older adults – the primary demographic group to partake in cruise tourism. While the cruise industry has largely rebounded following the end of these international restrictions, with several Canadian ports anticipating record-breaking cruise seasons in 2024, COVID-19 illustrated the industry's distinct vulnerability to pandemics.

Even more notable was the pandemic's impact on the container/cargo ship industry. The world has become progressively interconnected and interdependent with respect to the distribution and production of goods over the past three decades, as components and parts for products are sourced internationally and many other products are manufactured in other countries with lower labour costs. The rise of e-commerce has expanded markets internationally, as well as widening consumers' access to products from around the globe. Companies have thus created intricate international supply chains, premised on the "just enough, just in time" strategy of production, allowing them to minimize their inventories and dispatch shipments just as they are needed. Historically, this principle has been effective and efficient, successfully reducing storage costs and generating economies of scale that thereby reduce prices for consumers. In accordance with this principle of business, shipping cargo aboard container ships has become a crucial feature of international economies and ensuring citizens' access to goods that are critical for their daily lives.

The COVID-19 pandemic illustrated the tremendous ramifications that pandemics can have on the interconnectivity of the international economy. Upon the initial discovery of the coronavirus in China, the Chinese government implemented a lockdown of Wuhan in Hubei Province, which was the epicentre of the outbreak, and shuttered factories elsewhere in the nation. Given that China is a major producer of manufactured goods in the world, these closures had widespread impacts. Since factories were closed, they were no longer producing goods, and thus there were few goods to load into containers and onto ships for transport to international markets. Then, as the pandemic crept across international borders and found its way to all reaches of the globe, China resumed production while the rest of the world shut down. Though the supply issues were now remedied, demand issues took their place, since factories around the world could not utilize Chinese components (given their own closures) and lockdowns prohibited consumers from being able to purchase Chinese-sourced goods in local stores. Cargo shipments from China resumed but piled at international ports.

Transporting that cargo from the ports via truck was now an issue, too, given the tightening of international borders in response to the pandemic's spread. Truck drivers were also hesitant to travel into cities, regions, and countries experiencing surges in cases. Even those drivers willing to make the treks experienced difficulties, as stores and gas stations prohibited them from utilizing their facilities or outright refused to serve them. Moreover, given the closures of factories internationally, drivers found themselves delivering cargo to workplaces in which there were no employees to accept or process the incoming cargo, and which had no outgoing cargo of their own to ship. Since the movement of container shipments is at the expense of the receiving company (e.g., the receiving company pays for the containers to be loaded onto a ship and transported to a port for unloading, whereupon the ship then receives another load of full containers to transport onwards, at the expense of the next receiving company), such a lack of goods to transport interrupts this steady flow of container shipments. In addition to producing logistical difficulties due to the accumulation of empty containers at ports, where they block and hinder operations, the lack of products to fill containers means that there is no receiving company to assume the expense for the next leg of the containers' transit. As a result, one receiving company foots the costs for the containers' transit in both directions. Those higher shipping costs increase the price of the cargo and, inevitably, are passed along to consumers. Ports may experience further logjams and delays if dock workers refuse to unload and interact with vessels arriving with cargo out of fear of potential exposure.

Global pandemics can also impact shipping in the maritime arena through their disruption of alternate methods of transporting goods, as evidenced in the COVID-19 pandemic. Although perishable and high-value products are generally transported by air, often as cargo in passenger flights, interruptions to the air transit industry during the pandemic with the cancellation or restriction of flights produced drastic increases in air freight rates. More goods were consequently transported by ship – even perishable items, which was problematic given the extended transit times required for shipping via vessel as opposed to airplane – and thus a wider range of goods encountered the aforementioned challenges.

Pandemics furthermore interrupt maritime shipping on a more individual, personal level. International pandemics like COVID-19 often induce border closures, travel restrictions, port quarantines, and air transit cancellations. Such closures of key points of entry in turn deny crews the ability to go ashore, producing serious implications like the inability to change crews in the

event that new crews cannot arrive or old crews cannot depart. This inability to change crews creates humanitarian concerns respecting the crews' well-being, as well as concerns about the potential safety ramifications stemming from the crews' resultant fatigue.

Much as pandemics can impact the crewmembers aboard cargo and shipping vessels, they also can have significant repercussions for naval activities and operations. As with commercial vessels, navies encounter difficulties in isolating crewmembers prior to their deployment, as they, too, may be exposed to illness in the communities in which they live. As a result, in the early months of the COVID-19 pandemic, naval crews were isolated for two-week periods prior to their deployments to ensure, as much as possible, that no crewmember boarding the vessels was infected. Still, despite such precautions, several navy ships reported cases of coronavirus amongst their crews. Indeed, naval operations present distinct challenges in minimizing the spread of illnesses like COVID-19, given the tight quarters that render social distancing difficult, sickbays that were not equipped to accommodate large numbers of infected and infectious personnel, and, in the case of COVID-19, the potential for a crewmember to be infectious for several days before symptoms arise and their infection is apparent.

This combination of factors led to cases like that of the US Navy aircraft carrier USS *Theodore Roosevelt* in 2020. Following a port call at Vietnam, one crewmember tested positive for the virus in late March. Though he was airlifted from the vessel, and most of the 4,900 crewmembers were subsequently removed from the vessel after several weeks to isolate in Guam, over 1,000 – or nearly 20% – of USS *Theodore Roosevelt*'s crew contracted and tested positive for the virus.[278]

When a virus or illness strikes a naval crew so intensely, it can render the vessel inoperable. Precautionary measures taken to avoid exposure to viruses can similarly remove vessels from service. Indeed, at the beginning of the COVID-19 pandemic, two of Canada's Kingston-class vessels sailed home early from exercises off the West African coast, while two others bowed out of a counter-narcotics mission in the eastern Pacific Ocean to return home. Both withdrawals were not in response to infections among the crews but rather were a precaution. Such removals of vessels from operations and exercises not only diminishes the capability and presence of the Canadian Armed Forces but also reduces the Royal Canadian Navy's ability to train and practise its interoperability with allied navies. Pandemics can thus curtail a navy's ability to exercise its three key roles of naval diplomacy, constabulary, and warfighting.

Finally, pandemics also wreak havoc on naval budgets, specifically with regards to the budgets for the procurement and production of naval vessels. For instance, in Canada, the National Shipbuilding Strategy (NSS) continues to invest billions of dollars into revitalizing and recapitalizing the Canadian naval and coast guard fleets. Not only can pandemics impact such construction projects by potentially diverting funds and reallocating money from shipbuilding to the pandemic response efforts, but illness and its spread cause delays by interrupting global supply chains, increasing inflation, producing workforce challenges, and forcing temporary shutdowns in construction if workers are infected.[279] Therefore, global pandemics can significantly disrupt operations and activities in the world's maritime arena, impacting maritime leisure, economic, and security and defence activities. As the COVID-19 pandemic has illustrated, these disruptions can take several months and in some cases years to iron out.

Undersea Cables

In the 21st century, digital communications across international boundaries, continents, and global seas are, for many, a basic and even critical component of daily life. Once, these trans-oceanic communications, ranging from personal emails to money transfers, relied on satellite. Now, undersea cables carry nearly 99% of the world's trans-oceanic data,[280] offering data transfers that are higher quality, faster, greater in capacity, and more reliable than those attainable through satellites.

Undersea cables have an extensive history as a mode and method of communication, with their use stretching back to the 1840s. The early days of the undersea cable saw Britain (an initial leader in the technology) deploying them to enhance communication with its scattered and immense empire. Trading companies similarly utilized undersea cables to communicate with and disseminate instructions to their vessels. Nations also found them to be effective means by which to receive communications from and transmit directions to their militaries and diplomats. While these early cables traversed only short distances, crossing harbours, rivers, or, for instance, the English Channel, their success soon inspired efforts to expand their reach. Indeed, in the 1840s, investors quickly backed a proposal to lay an undersea cable across the Atlantic Ocean, stretching from Ireland to Newfoundland and onwards to the mainland. Though a promising prospect, laying an undersea cable stretching between continents was a complex and formidable task. US Navy Lieutenant Matthew Maury, who had performed survey work off the eastern coast of the US, mused in 1853 that laying an undersea cable across the Atlantic Ocean would certainly be possible in the undersea conditions in question. However, "I [do not] pretend to consider the question as to the possibility of finding *a time calm enough, the sea smooth enough, a wire long enough, a ship big enough*, to lay a coil of wire sixteen hundred miles in length."[281]

Indeed, the technical and logistical considerations surrounding such a groundbreaking undertaking were numerous. Often, questions regarding how to lay the cables, how to insulate them, and how to maintain a strong signal over such a distance required trial and error to resolve. Though initial attempts at installing trans-oceanic cables failed, the 1850s saw the first cables successfully crossing the Atlantic, and further cables connected Britain and India by the 1880s and crossed the Pacific Ocean in the early 1900s. Initially, these cables transmitted telegraph messages. As technology evolved, they began to convey telephone traffic, and now they are responsible for the transmission of a variety of communications and data, including telephone communications, money transfers, and internet data. While their initial speed of transfer for a telegraph was around 10 to 12 words per minute (a substantial increase in speed over the weeks-long process of sending a letter), technological improvements have enabled the transfer of sizeable amounts of data at nearly the speed of light. Such improvements (particularly the development of the fibre-optic cable) and the rise of the internet age with its constant push for more information created a new race to lay cables in the 1980s and 1990s. This, in turn, saw the investment of billions of dollars, the expansion of the cable system, and the replacement of existing lines. Since the early 2000s, the focus with respect to undersea cables has transitioned from the Atlantic Ocean to the Pacific.

Laying undersea cables is an expensive undertaking. As such, private consortia of operators have historically been – and continue to be – responsible for their construction, with private telecommunications firms like Microsoft and Google owning the majority of cables today. In the

21st century, these cables underpin much of modern society's systems and functions. Socially, these cables are now the basis of peoples' ability to communicate with each other across international boundaries and oceans. Economically, the international financial system relies on the undersea cable infrastructure to transmit information. For instance, the Society for Worldwide Interbank Financial Telecommunication (SWIFT) transmits, on a daily basis, "some 20 million messages to more than 8,000 banking organizations, security institutions, and corporate customers in nearly 200 countries, reconciling trillions of dollars' worth of assets across global financial markets."[282]

Given the extent of the world's dependency on these cables, their security has been and continues to be a cause for concern. Operators began to bury undersea cables in the 1980s to reduce their vulnerabilities. Still, however, certain risks remain. Anchors, fishing nets, offshore oil exploitation, dredging operations, ocean currents, and natural events like earthquakes can all inadvertently and unexpectedly cause injury to the cables. For instance, uncrewed US surveillance flights over and in Iraq shuddered to a halt in 2008 when an anchor snagged on and severed an undersea cable several hundred miles away, interrupting the connection between the uncrewed aircraft and their controllers, based in the continental US.[283] Similarly, the 2011 earthquake off Japan severely damaged undersea cables in that region.

In addition to these accidental or unforeseen damages, the intentional damaging of undersea cables has occurred, albeit rarely. Early in the technology's history, Britain realized that the cables, given their status as an integral communication means, were vulnerable to disruption during military conflicts and could be either compromised for information or cut to disrupt communications. While the 1884 Convention for the Protection of Submarine Telegraph Cables thus sought to prevent states from deliberately damaging cables, this has not entirely prevented malicious efforts to disrupt the communications they carry. The First and Second World Wars both saw the Germans and British attacking cables to disrupt the opposing side's communications. Soviet "fishing" trawlers "inadvertently" dragged and severed US cables in the Cold War, while the US tapped into Soviet cables. Within the past decade, in 2015 and 2018, there has been concern in the West about Russian submarines and vessels either conducting operations near or hovering over subsea cables.[284] These concerns prompted the US's 2018 defence budget to approve the construction of a second cable-repair/laying vessel for the US Armed Forces. Furthermore, while no confirmed terrorist attack has targeted submarine cables to this point, pirates did seize an 11-kilometre stretch of cable connecting Hong Kong, Vietnam, and Thailand in 2007 and tried to sell the cable as scrap. Piracy off the African coast has moreover delayed the laying of cables into Africa. Since the cable-repair and cable-laying vessels are slow and large, and transit a predetermined and specific route, they can be particularly susceptible to attack. Security experts also caution that the availability online of maps of the cable routes could aid hostile actors seeking to target undersea cables. While recent history has not seen an outright malicious attack on the world's undersea cable systems, such an attack is not inconceivable nor impossible.

Indeed, the extent of the world's dependency on these cables demands their redundancy, so that the loss of one cable would not take the entirety of the system offline. Building such total redundancy is, of course, exorbitantly expensive. Historically, operators laying new cables tended to do so in approximately the same locations, all opting to utilize the optimal routes between destinations across the ocean floor. Since this, too, creates risks, in that an attack or accident in the

region could damage multiple cables and disrupt several lines, undersea cable systems today generally prioritize redundancy in their arrangement and organization. They do so by implementing features like “mesh networks” and dual landing points to enable the transfer of services amongst networks in the event that one path is no longer operational. Modern technology is also capable of determining the precise location of damage in a cable to enable rapid repair, therefore increasing reliability.

Undersea cables are thus a strategic communications asset, spanning the world and proving integral for states’ militaries, economies, and citizens. Their military importance in conveying information would make the disruption of cable networks detrimental for military exercises and operations, which could elevate the value of such cables as targets for hostile state-based and non-state-based attacks. Though buried in the seabed, and thus out of sight, undersea cables remain vulnerable assets due to their significance as strategic, economic, and communication links between Canada and the rest of the world. Their protection, then, is a task that falls to the world’s navies, including the Royal Canadian Navy.

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[132] Based on an original submission by Dave Perry.
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[134] The process for the RCN's acquisition and procurement of equipment as described above includes only the major and primary activities involved. Generalizations and simplifications are made for the sake of brevity.
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[136] GoC, "Defence Procurement Strategy," last modified November 3, 2021, https://www.tpsgc-pwgsc.gc.ca/app-acq/amd-dp/samd-dps/index-eng.html.
[137] Some procurement projects are organized differently. For instance, the procurement strategy for the Arctic and Offshore Patrol Ship has followed a "design then build" approach.
[138] For the CSC, Canada selected Irving Shipbuilding in Halifax as the builder through an earlier competition. Thus, despite who won the contract, the CSCs will be constructed in its shipyard.
[139] Initially, the CSC procurement project was organized so that two contracts would be granted, one for the design and another for the combat systems integration package. The government thus received submissions from 12 qualified bidders in those two streams, before narrowing down the field by instructing the bidders to then divide into teams. Some companies subsequently withdrew their bids, and, eventually, only three teams offered bids. The successful team was comprised of Lockheed Martin, the prime and combat system integrator, and BAE Systems, the owner of the selected Type 26 Global Combat Ship design.
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[142] DND, Media Release: "Halifax-Class Modernization and Frigate Life Extension," 2018, https://www.canada.ca/en/department-national-defence/services/procurement/halifax-class-modernization.html. For more on the FELEX program, see *Maritime Engineering Journal*'s March 2017 special issue at http://www.cntha.ca/static/documents/mej/mej-82.pdf.
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[145] Public Services and Procurement Canada, Press Release: "Halifax-Class Frigates: Maintaining Canada's Federal Fleet of Combat Vessels," July 16, 2019, www.canada.ca/en/public-services-procurement/news/2019/07/halifax-class-frigates-maintaining-canadas-federal-fleet-of-combat-vessels.html.

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[147] Murray Brewster, "Canada's Submarine Fleet Spent 'Zero Days' at Sea Last Year: Government Documents," CBC News, February 11, 2020, https://www.cbc.ca/news/politics/submarines-canada-fleet-repairs-canadian-navy-1.5458632.
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[149] GoC, DND, "Backgrounder: Victoria In-Service Support Contract," July 4, 2013.
[150] "An army marches on its stomach," Oxford Reference, https://www.oxfordreference.com/display/10.1093/oi/authority.20110803095425331.
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[152] In the future, it is possible that artificial intelligence will assume responsibility, at least in part, for managing and tracking this information.
[153] MASIS was established in the late 1990s to attempt to manage materiel more effectively and in a way that required fewer personnel, in response to the growing capability of computers and the reductions in DND's personnel base. It became the primary program utilized by procurement personnel, maintenance crews, and engineers until the creation of DRMIS in 2010. See DND, Media Release: "In the News," *Frontline Defence*, 2012, https://defence.frontline.online/news/1235/drmis-resource-management-dnd.
[154] Public Service and Procurement Canada, "Defence Resource Management Information System: Integrated Support Services and SIGMA Integrated Support Services – Request for Proposal 2," last modified 2019, https://www.tpsgc-pwgsc.gc.ca/se-fm/2016/avril-april22-2016-eng.html.
[155] See DND, Media Release: "In the News."
[156] Canada was at the forefront of devising a system like DRMIS, in which even vessels actively deployed could partake. As a result, the system received international acclaim and attention, leading to Canada's involvement in the Defence Interest Group (DEIG), a 17-nation coalition that shares details about the implementation of Systems, Applications, and Products (SAP) related to supporting defence operations.
[157] Since heavy machinery is not always able to deliver food and other supplies to the storerooms and kitchens of a vessel, transporting such goods onto the ship and storing them often entails crewmembers passing bags and boxes along in a line until all material is stored in its proper location.
[158] For a discussion on the delays of the Hunter class, see Marcus Hellyer, "Australia's Hunter-Class Frigates Are Coming, but Maybe Not Soon Enough," *The Strategist*, November 26, 2020, https://www.aspistrategist.org.au/australias-hunter-class-frigates-are-coming-but-maybe-not-soon-enough/.
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[160] For information on the capabilities of the CSC, see DND, RCN, "The Canadian Surface Combatant: More than Just a Ship," October 16, 2020, https://www.canada.ca/en/department-national-defence/maple-leaf/rcn/2020/10/the-canadian-surface-combatant-more-than-just-a-ship.html. For discussion on the capabilities, see Xavier Vavasseur, "Royal Canadian Navy Unveils New Details on CSC Frigates," *Naval News*, September 11, 2020, https://www.navalnews.com/naval-news/2020/11/royal-canadian-navy-unveils-new-details-on-csc-frigates/.
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[162] "Exploring the Future of Canadian Naval Warfare."
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[164] Byers and Webb, "Titanic Blunder," 10.
[165] Canada, Report of the Standing Senate Committee on National Security and Defence, "Reinvesting in the Canadian Armed Forces: A Plan for the Future," May 2017.
[166] Operation *Caribbe* is the Canadian component of Operation *Martillo*, the multi-national counter-narcotic project that the US leads in the eastern Pacific Ocean and Caribbean Sea.
[167] Byers and Webb, "Titanic Blunder," 10.
[168] Government Response to "The Readiness of Canada's Naval Forces," Report of the Standing Committee on National Defence, October 16, 2017.
[169] Public Services and Procurement Canada, News Release: "Government of Canada Awards Contract for Minor Warships and Auxiliary Vessels In-Service Support for Canadian Armed Forces," July 12, 2023,

https://www.canada.ca/en/public-services-procurement/news/2023/07/government-of-canada-awards-contract-for-minor-warships-and-auxiliary-vessels-in-service-support-for-canadian-armed-forces.html.
[170] A blue-water navy operates in the open ocean. In contrast, a green-water navy operates nearby the coastline, while a brown-water navy operates close to coastlines or in rivers.
[171] RCN, *Leadmark 2050: Canada in a New Maritime World* (Ottawa: DND, 2016), vi.
[172] "Seaspan Shipyards Hosts Ceremonial Keel Laying for HMCS Protecteur," *Naval Technology*, January 17, 2020.
[173] Manaranche, "Canada Names and Launches First of New Protecteur-Class AOR Ships."
[174] Manaranche, "Canada Names and Launches First of New Protecteur-Class AOR Ships."
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[198] Since an onshore supporting commander generally tasks maritime patrol aircraft (MPA) to operate with task groups, such aircraft are not considered to be directly elements of the naval task group. RCN, *Leadmark 2050*, 43.
[199] RCN, *Leadmark 2050*, 44.
[200] Such threats could include attacks from non-state forces utilizing unconventional means (like using a speedboat packed with explosives to ram a warship) or traditional attacks from state forces under, over, or on the sea (such as those using torpedoes, missiles, bombs, or bullets). Today, naval task groups can also encounter threats stemming from electronic, acoustic, information, electro-optical, and electro-magnetic pulse attacks.
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