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Anchored in Vulnerability: Evaluating Canada's Naval Mine Countermeasures Preparedness: Is the Royal Canadian Navy “Ready Aye Ready”?

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JCSP 49 DL

Exercise Solo Flight

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ANCHORED IN VULNERABILITY: EVALUATING CANADA'S NAVAL MINE COUNTERMEASURES PREPAREDNESS: IS THE ROYAL CANADIAN NAVY "READY AYE READY"?

AIM

This service paper will examine the state of the Royal Canadian Navy's (RCN) Naval Mine Countermeasures (NMCM) capability. A comparative analysis with allied nations will show the urgent need for Canada to expedite the modernization and enhancement of its NMCM capabilities, with recommendations to the Director General Naval Force Development (DGNFD).

INTRODUCTION

In the context of modern warfare and maritime security, mine warfare is divided into two disciplines: Mining and Mine Countermeasures (MCM). Naval mines continue to be a significant threat and an efficient and cost-effective method of preventing access to strategic waterways, harbours, and ports.[1] In addition to causing substantial damage to infrastructure, naval vessels, and commercial shipping, naval mines can also be deployed by state and non-state actors. Moreover, the perceived risk of a harbour being mined can result in a substantial disruption to trade, potentially costing tens of millions of dollars per day as vessels would be forced to wait for entry or departure from port.[2]

There are many kinds of naval mines, such as contact mines, influence mines (mines activated by the magnetic, acoustic, or pressure signatures of passing vessels), and sophisticated smart mines equipped with advanced sensors and the ability to target specific vessels.[3] Furthermore, the proliferation of MCM technology has yet to eliminate the threat, as more recent mines are designed to avoid detection and neutralization.

Naval mines continue to be a concern for maritime security planners and naval forces worldwide, as seen most recently during the Ukraine/Russia war.[4] As a result, continuing efforts by the international community and industry are required to advance mine detection, clearance, and countermeasures technologies to reduce the threat of naval mines to operations and commerce.

With nearly half of Canada's waters being internal or territorial and the world's longest coastline at 242,042 km, the RCN has taken steps to bolster its NMCM

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[1] Department of National Defence, Royal Canadian Navy, *Concept for Naval Mine Countermeasures (NMCM)*, (Ottawa: Director General Naval Force Development, 2015), 2.
[2] "Economy," Association of Canadian Port Authorities, accessed May 7, 2024, https://acpa-aapc.ca/our-impact/economy/.
[3] "Naval Mine," Military Wiki, accessed May 14, 2024, https://military-history.fandom.com/wiki/Naval_mine.
[4] Gary Dixon, "Ukraine claims four mines dropped in grain shipping corridor by Russian air force," *TradeWinds*, Published October 25, 2023, https://www.tradewindsnews.com/bulkers/ukraine-claims-four-mines-dropped-in-grain-shipping-corridor-by-russian-air-force/2-1-1541247.

capability. A comparative analysis with allied nations will show Canada's vulnerability to naval mining, which poses a significant risk to national security and economic stability.

A comprehensive understanding of Canada's NMCM capability will be developed by drawing on insights from primary sources such as documentation, doctrine, and tactics of the Department of National Defence (DND), as well as secondary sources from allied navies such as the United States of America, the United Kingdom, the Netherlands, and Belgium.

DISCUSSION

Historical Overview

Evolution of Naval Mines

Naval mines have a long and varied history, dating back to ancient times when they were constructed using straightforward obstruction techniques such as submerged spikes and rocks. During the Medieval and Renaissance periods, "Greek fire" introduced more sophisticated strategies by setting barrels on fire and letting them float with the tidal stream toward enemy ships, paving the way for the Gunpowder Era's significant development of explosive-filled barrels.

Notably, during the American Civil War, Rear Admiral David Farragut famously exclaimed to Captain Drayton of the Hartford in the Battle of Mobile Bay in 1864, "Damn the torpedoes, full speed ahead!"[5] The torpedoes in the quote would not be what we would now think of as modern torpedoes but rather naval mines, showcasing their use as a significant threat to maritime operations. In the 19th century, the world witnessed substantial advancements in mine technology, most notably during the Crimean War with submerged wooden casks filled with gunpowder and chemical horns known as contact mines.[6] The critical role naval mines played in blocking enemy ports and disrupting maritime trade was highlighted during both World Wars.[7]

The developments in influence mines increased the lethality of naval mines, enhancing their effectiveness. These sophisticated naval mines are equipped with cutting-edge sensors and mechanisms that allow them to detonate autonomously based on detecting a potential enemy, making them formidable weapons in modern warfare.[8]

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[5] Rolando Machado, "'Damn the Torpedoes – Full Speed Ahead': Navy's First Admiral was Hispanic Hero," *America's NAVY*, published September 15, 2020, https://www.navy.mil/Press-Office/News-Stories/Article/2347790/damn-the-torpedoes-full-speed-ahead-navys-first-admiral-was-hispanic-hero/.
[6] Rob Hoole, "The Development of Naval Minewarfare," accessed May 8, 2024, https://www.mcdoa.org.uk/Development_of_Minewarfare.htm
[7] Hoole, "The Development of Naval Minewarfare."
[8] Ibid.

Examining the Contemporary Usage and Impact of Naval Mines

Naval mines enable military defence, maritime security, and counterterrorism operations. As defensive armaments, they can deter opponents and safeguard coastlines and maritime resources from hostile invasions. Strategically, they can effectively prevent access to essential waterways and harbours, thus protecting national interests. However, naval mines can also be used as an offensive posture, tactically deployed to disrupt enemy shipping lanes, impede maritime operations, and deny access to critical ports;[9] undermining the adversary's naval capabilities and imposing significant logistical and operational challenges.

The existence of naval mines also poses inherent dangers, as their indiscriminate characteristics can intensify tensions and diplomatic conflicts, especially in contested areas. In addition, technological progress has made modern naval mines more advanced and challenging to detect, creating significant difficulties for NMCM.

Despite their defensive capabilities, naval mines give rise to urgent environmental and humanitarian concerns, particularly in post-conflict situations where naval mines are frequently left uncharted and left in place after the conclusion of military conflicts, which poses an additional threat to civilians. To effectively identify and render these sophisticated explosive devices safe, employing inventive strategies and allocating resources toward state-of-the-art technology is necessary.

National Security and Economic Implications of Naval Mines

The direct threat mines pose to Canada is low, but not zero. The potential danger comes from countries having arsenals of naval mines and the means to deploy them through various platforms and in a covert fashion. The impact of the enemy mining strategic ports and chokepoints will disrupt maritime traffic, hinder commercial activities, and inflict significant economic losses.[10] Additionally, enemy mines threaten naval vessels and maritime operations, necessitating robust counter-mine efforts and enhancing maritime security measures to mitigate risks and ensure safe navigation in contested waters.

The economic impact of naval mines involves more than just military considerations; they also influence maritime commerce and trade routes worldwide.[11] Mines placed in commercial shipping lanes can impede maritime traffic and cause delays in cargo shipments, as recently seen in Ukraine.[12] This, in effect, then increases the cost of transportation and, ultimately, the cost of the goods for the consumer at the end of the chain. The potential mining and ease of covert mining of vital maritime infrastructure in Canada, which includes major strategic seaports such as Halifax, Vancouver, Prince

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[9] Department of National Defence, *CONCEPT FOR NMCM*, 4.
[10] Geneva Call, "Naval Mines and International Humanitarian Law," published April 5, 2019, https://www.genevacall.org/news/naval-mines-and-international-humanitarian-law/.
[11] Geneva Call, "Naval Mines and International Humanitarian Law."
[12] Dixon, "Ukraine claims four mines dropped."

Rupert, Montreal, and the St. Lawrence Seaway, would unquestionably significantly impact Canadian commercial activities. As a result, it highlights how important it is for the RCN to have the capability to respond to threats promptly and decisively.

The RCN's NMCM Capability and Future Trajectory

Mine Countermeasures Ships

The Kingston-class was brought into service in the mid-to-late 1990s to provide coastal defence and NMCM capabilities against mine threats to Canada's strategic ports and domestic sea lines of communications.[13] An in-service support contract oversees system repair, maintenance, and the installation of engineering modifications to support the ships.[14] The ships were built to commercial standards and maintained by their Lloyd's class.[15]

The original purpose of the Kingston-class acquisition was to conduct NMCM against mine threats to Canada and to offer a coastal defence capability.[16] The mechanical minesweeping equipment previously utilized onboard the Kingston-class is no longer used. One advantage of the Kingston-class is that it has maintained its ability to carry a variety of NMCM payloads. These include an upgraded route survey side scan sonar system for shallow and deep water that is attached to the deck of the ship and towed astern, in addition to the capacity to install a decompression chamber onboard, and the employment of specialized naval mine clearance divers.

The RCN routinely uses its platforms worldwide to support and defend Canadian interests, whether alone or in concert with other naval forces. The mine threat can materialize quickly and dramatically in scenarios where naval forces must operate close to an enemy's coastline or territorial waters, requiring NMCM capabilities appropriate to the threat's nature and potential.

The Kingston-class is no longer the best option for NMCM. Although the ships can reduce their magnetic signature via degaussing equipment, they lack a dynamic positioning system, acoustic signature reduction, and cathodic signature reduction.[17] Furthermore, the ship's utility in this role is severely limited by its large physical size and excess crew compared to specialized MCM platforms, as well as its lack of shock protection and an integrated mine operations system capable of linking into higher-level MCM Command and Control (C2) systems. Although the Kingston-class is no longer fit

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[13] Department of National Defence, Royal Canadian Navy, *KINGSTON-CLASS CONCEPT OF EMPLOYMENT*, (Ottawa: Director General Naval Force Development, 2021), 1.
[14] Department of National Defence, Royal Canadian Navy, *KINGSTON-CLASS CONCEPT OF EMPLOYMENT*, 1.
[15] A ship classification that establishes and maintains technical standards for the construction and operations of ships and offshore structures; Department of National Defence, *KINGSTON-CLASS CONCEPT,* 4.
[16] Ibid., 4.
[17] Ibid., 7.

to function as a dedicated MCM vessel deep within a Mine Threat Area (MTA),[18] it can still be used, albeit restrictedly, as a standoff platform for off-board NMCM systems. The first Kingston-class ship is scheduled for decommissioning in 2025, with the last ship ceasing operations in 2030, unless an additional life extension is approved.

As reported by the current Commander of the RCN to CBC News, the RCN is considering the possibility of deploying "ghost fleets," which are warships that do not require crews.[19] He stated that naval planners are currently conducting a new fleet mix assessment examining the various types of autonomous ships that may be available.[20]

The Role of Clearance Divers in NMCM

The RCN clearance divers are underwater specialists who have received extensive training and are tasked with providing mine countermeasures diving, maritime explosive ordnance disposal, and underwater engineering support worldwide on behalf of the Canadian Armed Forces (CAF).21 Fleet Diving Unit Atlantic (FDU(A)) in Halifax, Nova Scotia, and Fleet Diving Unit Pacific (FDU(P)) in Esquimalt, British Columbia, are the primary locations where clearance divers are stationed. Smaller detachments can be found within the Canadian Special Operations Forces Command and at the Experimental Diving and Undersea Group in Toronto, Ontario.

The RCN utilizes Uncrewed Underwater Vehicles (UUV) to locate Unexploded Ordnance (UXO). Clearance diver teams are dispatched to locate, identify, and neutralize the UXO using specialized procedures or controlled demolition systems.[22] The RCN does not currently have active NMCM search and disposal systems that can operate in a mine-threat environment without incurring increased risk to naval assets and sailors. Presently, naval clearance divers are employed to identify and physically dispose of potential naval mines. While effective, clearance divers are extremely limited in coverage rate, and the process is both time-consuming and inherently physically risky for personnel.

New NMCM Equipment for the RCN

The RCN depends on clearance divers for ordnance sea mine disposal at depths up to 81 meters. Consequently, the RCN needs more capability for full-spectrum naval minehunting, which includes detecting, classifying, localizing, re-acquiring,

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[18] When enemy mining is suspected or confirmed, an assessment must be made to identify the limits of all potentially mined waters – the Mine Threat Area (MTA). This is the area where MCM operations will be conducted.
[19] Murray Brewster, “The navy is looking at deploying 'ghost fleets' — warships that do not need crews,” *CBC News*, published May 23, 2024,
[20] Brewster, “The navy is looking at deploying 'ghost fleets' — warships that do not need crews.”
[21] Department of National Defence, Royal Canadian Navy, *Naval Diving Operational Concept Of Employment (OCE)*, (Ottawa: DND, 2004), 15.
[22] Department of National Defence, Royal Canadian Navy, *Naval Diving Operational Concept Of Employment (OCE)*, 16.

identifying, and effectively disposing of sea mines at depths of at least 200 meters, as outlined in the RCN Concept of NMCM.[23]

To "deter naval mining and to respond appropriately to mined Canadian waters," and "contribute to the defence of North America," Leadmark states that "advanced route survey, minehunting, and mine clearance ability" are required.[24] As such, in 2007, the RCN started a project to fill this capability gap greater than 81 meters with the Remote Minehunting and Disposal System (RMDS) project. The objective of the RMDS project is to invest in UUV, autonomous underwater vehicle systems, and the technology necessary to develop a modular, standoff NMCM capability. The RCN will acquire two modular RMDS payloads comprising a standard 20' shipping container, one for each coastal formation. Although initially designed for employment on the Kingston-class, they contain modular sub-systems that are portable and deployable from other RCN ships and vessels of opportunity.[25] The RMDS shall allow the RCN to conduct the full spectrum of naval minehunting operations up to 200M+, enhancing underwater domain awareness and allowing for the detection, classification, localization, reacquiring, identification, and disposal of naval mines and maritime improvised explosive devices that threaten Canadian interests or impede naval operations by RCN ships.[26]

The RCN's Concept for NMCM

The RCN has a strategic plan that guarantees the generation of sufficient sailors with the right level of mine warfare training to evolve its NMCM capability and structure. Like this, the RCN must be ready to deploy and oversee new capabilities like the RMDS and maritime uncrewed systems. In any case, Canadian NMCM capabilities will be centred around:

- defending our platforms and those of our coalition partners;
- protecting non-combatant commercial maritime traffic; and
- keeping critical ports and waterways clear of mines.[27]

The RCN NMCM Objectives include:

- to invest in the NMCM capabilities necessary to evolve the RCN into a modern, agile, combat effective Future Fleet;
- to ensure freedom of manoeuvre while conducting operations in littoral areas;

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[23] Department of National Defence, *CONCEPT FOR NMCM*, 4.
[24] Department of National Defence, *Royal Canadian Navy, Canada in a New Maritime World: Leadmark 2050*, (Ottawa: DND, 2017), 155-156.
[25] Department of National Defence, *Royal Canadian Navy, Remote Minuting and Disposal System (RMDS) Project Brief*, (Ottawa: Director General Naval Force Development, 2024), 4.
[26] Department of National Defence, *Royal Canadian Navy, Remote Minuting and Disposal System (RMDS) Project Brief*, 4.
[27] Department of National Defence, *CONCEPT FOR NMCM*, 5.

- to take advantage of the enhanced capability and greater safety provided to platforms and sailors by advanced technology and training, and
- to maintain the RCN's ability to integrate and operate effectively with its mission partners across the full spectrum of operations.[28]

Assessing Allies' NMCM capability

United States of America

Eight out of fourteen Avenger-class minesweepers are still in service with the United States Navy (USN). These vessels are made to be mine hunter-killers, able to locate, identify, and eliminate both bottom and moored mines.[29] The hulls are made of wood with a fibreglass covering.[30] This design gives the ship a low magnetic signature and makes the hull resistant to a nearby mine explosion. The ships use remotely operated mine disposal systems, remotely operated vehicles (ROV), and sophisticated hull-mounted minehunting and classification sonar for mine neutralization.[31]

The USN declared operational capability for its entire mine countermeasures mission package in May 2023. The package will operate from USN littoral combat ships and other potential C2 platforms. However, traditional minesweeping is still a critical capability for the USN.[32] The mission package consists of four central systems to locate, identify, and destroy sea mines: the uncrewed influence sweep system and mine-hunting sonar, which are towed behind the mine countermeasures Uncrewed Surface Vessel (USV); and the "airborne laser mine detection system" and "airborne mine neutralization system," both of which are operated from USN MH-60 Seahawk helicopters.[33]

United Kingdom

The Royal Navy currently operates nine Hunt-class and eleven Sandown-class minesweepers, with ten Sandown-class vessels having been sold or loaned to other navies (three to the Estonian Navy, three to the Royal Saudi Navy, two to the Romanian Naval Forces, and two to the Ukrainian Navy).[34] These vessels are equipped with two underwater remote-controlled mine-disposal vehicles. Constructed with glass-reinforced plastic hulls to mitigate detection by sea mines, they feature sophisticated equipment, including lighting systems, low-light-level black and white cameras, and colour cameras.

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[28] Ibid., 6.
[29] "Avenger Class Mine Countermeasures Ships," Military.com, accessed May 8, 2024, https://www.military.com/equipment/avenger-class-mine-countermeasures-ships.
[30] "Avenger Class Mine Countermeasures Ships," Military.com
[31] Ibid.
[32] Megan Eckstein, "U.S. Navy declares its mine countermeasures suite ready for operations," *Defence News*, published May 11, 2023, https://www.defensenews.com/naval/2023/05/11/us-navy-declares-its-mine-countermeasures-suite-ready-for-operations/.
[33] Eckstein, "U.S. Navy declares its mine countermeasures suite ready for operations."
[34] "Sandown-class minehunter," Wikipedia, accessed May 10, 2024, https://en.wikipedia.org/wiki/Sandown-class_minehunter.

They are controlled via a 2,000-meter fibre-optic cable.[35] Additionally, high-resolution sonar systems are integrated into the vessels. They can detect and classify objects the size of a soccer ball up to 1,000 meters away, facilitating the clearance of mines to ensure safe passage for larger naval forces.[36] Following detection, mines are destroyed by the ship's clearance diving teams or the onboard SeaFox Mine Disposal system.[37]

In line with strategic advancements, the Royal Navy has commenced a transition from crewed minehunters to autonomous systems, slated for completion by 2033.[38] This initiative comprises autonomous vessels, six mission systems, and three Logistics Support Vessels.[39] These autonomous vessels are versatile and capable of manual operation, remote control, or pre-programmed autonomous mission execution without human intervention. Equipped with advanced sensors for mine detection and full mine disposal capabilities utilizing ROVs, they also can simulate acoustic or magnetic signatures of ships to trigger mines or confirm their presence while being towed behind the vessel.[40] Additionally, UUVs can be towed astern to provide side scan sonar capabilities and advanced planning and analysis software for route survey operations. These autonomous systems are intended to operate from a C2 platform, supporting mine countermeasures tasks in the waters around the U.K. and Europe.[41]

Netherlands and Belgium

In April 2018, the Netherlands and Belgium signed a memorandum of understanding to collaborate on procuring new MCM vessels.[42] This strategic agreement involves each nation acquiring six new MCM vessels equipped with advanced uncrewed systems, such as uncrewed surface, aerial, and underwater vehicles. These vessels will also be fitted with towed sonars and ROVs to identify and neutralize mines.

The upcoming MCM vessels are specifically designed to primarily operate using autonomous technology to detect, classify, and neutralize mines.[43] Designed to endure underwater detonations, these ships possess minimal acoustic, electrical, and magnetic signals, perfectly conforming to the operating requirements.[44]

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[35] "Equipment / Ships SANDOWN CLASS," Royal Navy, accessed May 10, 2024, https://www.royalnavy.mod.uk/equipment/ships/sandown-class.
[36] "Equipment / Ships SANDOWN CLASS," Royal Navy.
[37] Ibid.
[38] "Royal Navy autonomous mine hunting at the sharp end," *Navy Lookout*, published March 30, 2023. https://www.navylookout.com/royal-navy-autonomous-mine-hunting-at-the-sharp-end/.
[39] "Royal Navy autonomous mine hunting at the sharp end," *Navy Lookout.*
[40] Ibid.
[41] Ibid.
[42] "Belgium and the Netherlands Signed the MoU for New Frigates & MCM Vessels*," Global Defence News,* published June 9, 2018. https://www.armyrecognition.com/news/navy-news/2018/belgium-and-the-netherlands-signed-the-mou-for-new-frigates-mcm-vessels.
[43] "Belgium and the Netherlands Signed the MoU for New Frigates & MCM Vessels*," Global Defence News*.
[44] Ibid.

The procurement solution implemented by the Royal Netherlands Navy and Belgian Naval Component signifies a significant change in mine warfare tactics. This creative solution, which adopts a standoff strategy, dramatically increases the effectiveness of area coverage in mined zones while reducing dangers to both personnel and the C2 platforms.

Table 1: MCM Capability by Country

Capability	Systems	Canada	United States of America	United Kingdom	Netherlands	Belgium
Detection & Classification	Sonar Systems					
	Magnetic and Acoustic Sensors					
Identification	Remotely Operated Vehicles					
	Autonomous Underwater Vehicles					
Neutralization	Mine Disposal Vehicles					
	Divers					
Sweeping	Mechanical Sweep System					
	Influence Sweep System					
Protection & Countermeasures	Mine Countermeasure Vessels					
	Uncrewed Surface Vehicles					
Data Analysis & Integration	Command and Control Systems					
	Geospatial Information Systems					

Advanced Technologies	Synthetic Aperture Sonar					
	Machine Learning and AI					
	Airborne Detection & Neutralization					

Table 1 presents a comparative summary of NMCM capabilities between Canada and its allied nations, as reviewed in this service paper. This table offers a visual overview using colour coding: green indicates possession of the capability, yellow signifies limited or developing capability, and red denotes the absence of the capability.

CONCLUSION

In conclusion, this service paper has analyzed the RCN's NMCM capability, emphasizing its positive aspects and areas that require enhancement. Canada needs autonomous systems, and many of them, to keep sailors out of the naval minefield. The comparison with allied countries, as shown in Table 1, highlights the immediate requirement for Canada to upgrade and strengthen its NMCM capabilities to address emerging security risks in maritime areas.

Mines pose a low but not zero threat to Canada. Therefore, Canada must be ready to respond quickly. Although the RCN has improved its NMCM capability by starting the RMDS project, more remote and autonomous systems are needed. The outdated Kingston-class vessels, although adaptable, do not possess the specific capabilities necessary for contemporary mine disposal operations. Moreover, depending on naval clearance divers for mine disposal entails notable hazards and limitations regarding coverage rate and operating efficiency.

Lastly, the increasing number of advanced mines and improvements in mine warfare techniques require inventive strategies and cutting-edge technologies to accurately identify, disable, and minimize the consequences of these dangers. Canada should emulate the mine warfare tactics of the Netherlands and Belgium, which employ a standoff strategy. This approach significantly enhances the coverage of mined areas and minimizes risks to crew and C2 vessels.

RECOMMENDATIONS

After analyzing the RCN's current NMCM capabilities against other NATO countries, it is recommended that DGNFD allocates resources to commence a new project to acquire the following equipment and technologies to improve the RCN NMCM capabilities:

- Uncrewed Surface Vessels (USVs): equipped with sophisticated sensors and artificial intelligence algorithms that will improve the ability to gather information and detect mines remotely. The USVs must be able to function independently or be operated from a distance to conduct surveys and detect potential naval minefields in shallow rivers and coastal regions with an uncrewed influence sweep system and mine-hunting sonar, which are towed behind the USV;

- Uncrewed Aerial Vehicles (UAVs): by acquiring UAVs for quick airborne observation, the RCN will be able to support mine countermeasure operations and locate possible naval minefields in coastal areas. The UAVs must have advanced image sensors that can quickly identify and evaluate the presence of mines, improving the understanding of the situation and the effectiveness of operations; and

- MCM Vessels: acquire a minimum of four commercial-off-the-shelf C2 platforms (min two per coast) based on the Netherlands and Belgium design. They will function as operational platforms for deploying and supporting the RMDS that are already implemented (although only two systems, additional systems will be needed), as well as USVs and UAVs. This will allow the vessel and crew to remain outside the Mine Danger Area (MDA).[45] These vessels must be built with non-ferrous hulls, which helps diminish their magnetic signatures and reduces the likelihood of mines triggering during NMCM operations. Integrating hull-mounted sonar equipment will improve the MCM vessel's ability to conduct underwater surveillance and identify mines in shallow water and coastal zones. These specialized vessels will be a reliable and adaptable base for organizing NMCM operations, guaranteeing efficient deployment and integration of the RCN's NMCM capabilities.

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[45] Established around the position of known mines, suspected mines, mine lines and minefields to bound the limits of the danger. MDAs can be established in various geometric sizes and shapes (circle, rectangle, square, polygon, etc.) depending upon the number and distribution of mines in the area. Only vessels actively engaged in MCM should operate in a MDA.

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