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JCSP 49

Service Paper

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PCEMI n° 49

Étude militaire

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CANADIAN FORCES COLLEGE - COLLÈGE DES FORCES CANADIENNES

JCSP 49 - PCEMI n 49
2022 - 2023

Service Paper – Étude militaire

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AIM

1. The aim of this paper is to examine the concept of Uncrewed[1] Surface Vessels (USV) and their employment with the Royal Canadian Navy (RCN).

INTRODUCTION

2. This paper will examine the concept of USV employment in the maritime domain. The paper will review current uses by Canada's allies, look at the value proposition for the use of USV, and consider some of the requirements that would be necessary should the RCN procure a squadron of USV. Due to the scope of this paper, focus will be maintained on surface vessels, though in realistic operations, there is a close relation with Uncrewed Undersea Vessels (UUV) and Uncrewed Aerial Vehicles (UAV).

DISCUSSION

Allied Use of USVs

United States of America

3. Canada's first and foremost ally the United States is deep into research of USV. In a congressional report in 2020, the case was laid out for the acquisition of various types of USVs. They categorize USV into Extra-Large, Large, Medium, Small, and Extra-small USV. The focus for augmenting their fleet is on Large-USV (LUSV) and Medium-USV (MUSV) for a mix of roles to provide a more distributed fleet architecture. These vessels would be pier-side launched in contrast to Small-USVs (SUSV) which can be launched form other United States Navy (USN) vessels. [2]

4. In an update provided by the Program Manager for Unmanned Maritime Systems, Captain Pete Small explained the envisioned role for LUSV and MUSV. The intent would be for LUSV to provide distributed fires and some sensing capability to act as an adjunct magazine for other surface combatants, and MUSV to provide distributed sensing and communications relays, thus masking the location and presence of crewed surface combatants.[3]

Australia

5. Canada's allies form down under are conducing the Patrol Boat Autonomy Trial (PBAT). This will see the Royal Australian Navy (RAN) Armidale-class ship, HMAS *Maitland* converted

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[1] Although colloquially in the RCN we use the term "Uncrewed" to be more gender neutral, the term "Unmanned" is prevalent throughout the international community and is much more commonly used. The terms will be used interchangeably throughout the paper, yielding to the given name of an entity where appropriate.

[2] Ronald O'Rourke, 'Navy Large Unmanned Surface and Undersea Vehicles: Background and Issues for Congress', *Congressional Research Service*, no. R45757 (17 September 2020): 1.

[3] Pete Small, 'Unmanned Maritime Systems Update'.

into a USV. The *Maitland* was selected as she was being decommissioned, and so she will be de-armed and transferred to Austal Industries for the trials. The program is designed to test the USV in various modes such as: manned, unmanned but remotely piloted, and fully autonomous.[4] Throughout this program, the RAN will collaborate with the USN who are conducting similar research with Austal in converting the Expeditionary Fast Transport USNS Apalachicola (EPF-13), to be an autonomous fast supply ship.[5]

United Kingdom

6. The allies from across the pond in the Royal Navy (RN) are hard at work incorporating the Maritime Demonstrator For Operational eXperimentation (MADFOX) into their fleet.[6] Although detailed specifications have not yet been released in an unclassified environment, it is known that the USV is capable of achieving speeds of 40 kts, operating up to 25nm from shore- or ship-based controllers. Amongst the various sensors fitted are a Lowrance short-range radar, an electro-optical/infrared (EO/IR) camera that can collect high-resolution images under a broad range of weather conditions, and various other sensors for threat detection and identification.[7]

7. During Robotic Experimentation and Prototyping using Maritime Uncrewed Systems (REPMUS) Exercise 2021, the RN deployed the MADFOX USV as a part of the combined joint amphibious operation. As a part of the theme foe the exercise, there was a large reliance on autonomous systems. In one serial information was received from a Puma UAV which spotted a threat vessel. The Puma transmitted the information to an operation centre ashore. With this information the threat was evaluated and the MADFOX was tasked to engage the target. It launched a missile which successfully engaged the target. During another serial, marines were conducing an amphibious landing, the MADFOX USV provided covert seaborne surveillance of enemy troop movements which were relayed to the assault force already ashore who were able to make an informed assessment of the enemy strength and movement before conducting their attack.[8]

8. Across the spectrum of our allies there is an equally vast spectrum of USV being considered for deployment in support of naval forces. What must be considered next is the value proposition gained by the use of USV.

Value Proposition and Benefits

9. There are many benefits to using USV and a few of them will be examined in this paper. For the benefit of completeness, the USN platform will be shown, although it is not likely that such a platform could be incorporated in the RCN with both a major investment of capital funds as well as a shift in fleet doctrine.

[4] Benjamin Felton, 'Austal to Convert Decommissioned RAN Patrol Boat into USV', Naval News, 10 May 2022.
[5] Brandon Vigliarolo, 'Navy Deploys Autonomous Ship Designed to Run without Humans', The Register, 22 February 2023.
[6] Royal Navy, 'New Autonomous Vessel Delivered to Royal Navy', RN Homepage, 26 March 2021.
[7] Baird Maritime, 'Madfox – USV Designed for Surveillance and Force Protection Missions', 4 August 2021.
[8] Dorian Archus, 'Royal Navy Launches Missile from MADFOX USV in REPMUS Exercise', Naval Post, 15 October 2021.

10. Numerous studies into the viability and affordability of USV have been conducted by the civilian commercial market. One such study highlighted that "[t]hose who embrace the technology advocate economic, safety and environmental benefits. For example, reduced number of mariners at sea brings wage savings and reduced risk of human errors that can lead to environmental disasters."[9]

11. The benefits in reduced human error are being realized by the fact that the humans involved in the operation can be located ashore. With less personnel required, the rotation of those operating the vessels can be greatly ameliorated. Although the risk of human error is not eliminated, it can be greatly mitigated in this regard.[10]

12. During the 2023 Surface Navy Associate National Symposium, Rear Admiral Fred Pyle, the U.S. Navy's Director of Surface Warfare explained that the USN is working towards Distributed Maritime Operations (DMO).[11] The concept is explained in more detail in a 2020 Congressional Report. It explains that the current fleet ratio of Large Surface Combatants (LSC; cruisers and destroyers) to Small Surface Combatants (SSC; frigates and littoral combat ships) is 2:1. In order to distribute the concentration of maritime effects currently residing in the LSC, the USN under DMO would shift to a fleet composition of 1:2:3:4, that being LSC:SSC:LUSV:MUSV. This would see a shift from the primacy of LSC and increase the role of SSC, all supposed by USV.[12]

13. The advantages of DMO fall into three main categories. Complicating the adversary's targeting solution, reducing the aggregate risk of loss to the fleet, and increasing adaptability through modularity and reconfigurability.

a. *Complicate Targeting.* Currently the USN's focus on LSC results in there being fewer combatants in the battlespace for the enemy to contend with. While engaging enemies such as China which can easily field and target a large force, it is unwise to concentrate one's force in fewer number of LSC. The advantages can be seen with this simple numeric example. Given a current fleet of 20 LSC and 10 SSC under a 2:1 force ratio results in fielding 30 ships. Shifting this to a DMO model with a 1:2:3:4 ration would see 10 LCS, 20 SSC, 30 LUSV, and 40 MUSV for a total of 100 ships.

b. *Reduce aggregate risk.* This advantage is easy to conceptualize, in the example of force ratios, LSC make up 66% of the current fleet composition making them a probable target of an attack, given their larger numeric presence in the battlespace and the prevalence of their use. Conversely, under DMO model, LSC make up

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[9] Trudi Hogg and Samrat Ghosh, 'Autonomous Merchant Vessels: Examination of Factors That Impact the Effective Implementation of Unmanned Ships', *Australian Journal of Maritime and Ocean Affairs* 8, no. 3 (2016): 206.

[10] Hogg and Ghosh, 207.

[11] Xavier Vavasseur, 'Video: Interview with RADM Pyle on DDG(X), LUSV, DDG 51 Flight III, Frigate...', Naval News, 7 February 2023.

[12] O'Rourke, 'Navy Large Unmanned Surface and Undersea Vehicles: Background and Issues for Congress', 2–4.

only 10% of the combatants. Additionally, 70% of the combatant are uncrewed, making their loss, though regrettable, much more palatable.

c. *Adaptability.* With the continuous and rapidly changing operational environment, the ability to produce many more smaller combatant vice fewer large combatant allows for a greater degree of adaptability. Additionally, vessels that do not require accommodations for human crew can achieve space- and cost-saving in the elimination of living space and hotel utilities.[13]

Conceptual Requirements for USV Employment

The MUNIN Project

14. In 2013 the European Commissions funded a collaborative research project called the Maritime Unmanned Navigation through Intelligence in Networks (MUNIN). The object of the project was to determine the economic feasibility of uncrewed merchant vessels to support the European Union's increasing need for global shipping. The problems faced were: a significant increase in transport volumes, growing environmental requirements, and a shortage of seafarers. The project defined an autonomous ship as a vessel primarily guided by automated on-board decision systems but controlled by a remote operator in a shore side control station.[14] Many parallels can be drawn from the methods of control to the technology required for implementation of remote autonomous system (RAS). The following is an example of the required systems to operate a fleet of remote autonomous ship developed by the MUNIN project.[15]

a. The project determined that the following entities would be required for the successful implementation of RAS. An advanced sensor module, and autonomous navigation system, and autonomous engine and monitoring control system, and a shore control centre comprised of the following positions: a shore control centre operator (SCCO), a shore control centre engineer (SCCE), and a shore control centre situation room team (SCC-SRT).

b. The advanced sensor module would be required to provide the control centre the appropriate level of situation awareness to make decisions should intervention be required. This is an example of a human-on-the-loop process (as opposed to human-in-the-loop) whereby the mission (voyage) can be loaded then executed by the autonomous navigation system. Should a situation arise that the system's algorithm either can not solve, or it triggers a preset condition, a SCCO can intervene and provide a guidance. This could be a situation such as the detection of a new weather pattern that the defined voyage path does not allow the ship to

[13] O'Rourke, 5.
[14] MUNIN, 'Research in Maritime Autonomous Systems Project Results and Technology Potentials', Project Website, 2016.
[15] MUNIN.

avoid. In the case the SCCO can update the voyage plan to permit a path for the ship to avoid the storm.

c. Without a crew onboard, advanced autonomous engine and monitoring control system would be required to ensure the engineering plant continues to operate within specified parameters. The plant can be monitored by the SCCE who is situated within the control centre to support the SCCO.

d. If the ship's situation is too complex for the autonomous navigation system, control of the ship can be assumed by the SCC-SRT. A replica of the ship's bridge will be in the same facility as the shore control centre. Using this bridge simulator, the SCC-SRT can take direct control of the ship and operate it remotely as though they were there. This is another reason for the advanced sensor module to be able to provide the requisite sensor data to replicate the bridge experience for the SCC-SRT.

15. Although this concept of operations was developed for a merchant ship, it can easily be seen how the concept could be transferred over to a fleet of autonomous ISR platforms. One could imagine a squadron USV ISR platforms patrolling a designated area, all controlled from a Maritime Component Commander's (MCC) Maritime Security Operations Centre (MSOC) somewhere ashore. The vessels could work in tandem in a machine learning (ML) enabled command and control (C2) network to detect specified vessels of interest (VOI). Once localized though electronic warfare (EW) triangulation, an appropriate asset could be vectored on to intercept, or tracking could simply continue until handover to an appropriate authority could be conducted.

16. A scenario such as the one above would be extremely useful in locations where vast distance/areas need to be surveyed into to maintain a level security in the area. For example the Gulf of Aden, an area of 410,000 km^2. The maritime community has great difficulty in securing such a large area against piracy. The difficulty lies in the ratio of available ships to the area to be covered and the response time of ships that may be out of position patrolling a different area of their assigned zone.[16] Instead of committing many LSC to the area to be patrolled, deploy a squadron of RAS ISR Interceptors with advanced sensing capabilities in the visual, IR, and EM spectrums suited to detecting pirate activity. Pair this RAS with UAVs and an amphibious assault ship, outfitted for sea control and the response time could be greatly reduced and more attacks against civilian shipping could be disrupted.

Crewing Requirements

17. An often-propagated misconception about USV is that the 'U' for uncrewed means that there will be reduction in the personnel requirements. A wise (and dashing) naval officer once said, "*there's nothing uncrewed about Uncrewed*".[17] The idea behind this statement is the even USV will require crews, it is just that these crews will be providing different functions. A RAND Corporation research report echoed this sentiment and identified several issues that may arise

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[16] Rear Admiral (ret) Terry McKnight, 'End Piracy in the Gulf of Aden', U.S. Naval Institute, 1 June 2017.
[17] Cdr Christopher Taitt, 'Email with Author Re Remote Autonomous Systems', 22 February 2023.

with USV. Uncrewed vessels are not 'uncrewed', they more so are 'uninhabited'. The crews required to support an USV often surpasses that required of a crewed platform with a similar concept of operation.[18]

18. Given that USV are uncrewed, certain functions may need to be shifted elsewhere in order to maintain the same level of operational effectiveness. For example, when a ship has a crew, that crew and their commander can be relied upon to provide leadership, decision making, and command assessments of the situation around the vessel. With a USV these functions could be performed by personnel in an MSOC, if appropriately advanced sensors allow for that kind of remote assessment. This will however require consideration to be applied to having personnel available on watch to conduct these kinds of assessment and provide the necessary leadership to the team.

19. Like the MUNIN example, there may arise a situation where a vessel will need to be taken under the control of human operators. To this end, a setup like that proposed by the MUNIN project would be required to be installed within already established operation centers or alternatively, new fit for purpose facilities will need to be constructed for this reason.

Locations

20. The locations for USV facility operations can be more dispersed than normal naval facilities. An example can be taken from the UAV community, where the control centre can be located greatly dispersed from the landing/docking facilities. For medium through XL-USV, a port and docking facility will be required. Depending on the concept of operations, it is likely that the USV will be brough under human control for the entry into harbour. Thus, appropriate crews and facilities to support such operations will be required.

CONCLUSION

21. This paper has presented a brief overview of the range of USV that Canada's allies are pursuing and examines the value proposition of USV though the pursuit of Distributed Maritime Operations. Finally, an examination of some conceptual requirements for the operation of USV, though these will differ greatly depending on the nature of the USV operated.

RECOMMENDATION

22. As the US is our closest neighbour and ally, we often find ourselves comparing our capabilities to them. However, given the disparity in fleet size and budget, it is not a realistic comparison. Nations such as Australia and New Zealand are a more realistic comparison and pursuit of a similar capability as those nations would be a realistic goal. To that end, should Canada be willing to allocate the necessary resources, this paper recommends the acquisition of medium sized USV to expand our ISR capabilities. As a stretch goal, should the will be there, a

[18] Scott Savitz, National Defense Research Institute (U.S.), and United States, eds., *U.S. Navy Employment Options for Unmanned Surface Vehicles (USVs)* (Santa Monica, Calif: Rand Corporation, 2013), 47.

LUSV in the style of vertical launch system (VLS) ship would provide a great force multiplier to the new Canadian Surface Combatant with a limited 32-cell VLS.

Annex(es): Annex A – Bibliography
Annex B – Glossary of Acronyms

ANNEX A

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ANNEX B

GLOSSARY OF ACRONYMS

Note: “Uncrewed” and “Unmanned” can be used interchangeably, see *Supra* note 1.

Acronym	Meaning
C2	Command and Control
CSC	Canadian Surface Combatant
DMO	Distributed Maritime Operations
ISR	Intelligence, Surveillance, and Reconnaissance
LSC	Large Surface Combatants
LUSV	Large Uncrewed Surface Vessels
MADFOX	Maritime Demonstrator For Operational eXperimentation
MCC	Maritime Component Commander
ML	Machine Learning
MSOC	Maritime Security Operations Centre
MUNIN	Maritime Unmanned Navigation through Intelligence in Networks
MUSV	Medium Uncrewed Surface Vessels
PBAT	Patrol Boat Autonomy Trial
RAN	Royal Australian Navy
RAS	Remote Autonomous System
RCN	Royal Canadian Navy
REPMUS	Robotic Experimentation and Prototyping using Maritime Uncrewed Systems
RN	Royal Navy
SCCE	shore control centre engineer
SCCO	shore control centre operator
SCC-SRT	shore control centre situation room team

Acronym	Meaning
SSC	Small Surface Combatants
SUSV	Small Uncrewed Surface Vessels
UAV	Uncrewed Aerial Vehicle
USN	United States Navy
USV	Uncrewed Surface Vessels
UUV	Uncrewed Undersea Vessels
VLS	Vertical Launch System
VOI	Vessels of Interest
XLUSV	Extra-large Uncrewed Surface Vessels
XSUSV	Extra-small Uncrewed Surface Vessels