EPiC Series in Technology
Volume 2, 2024, Pages 74–80
Proceedings of the International Conference on
Maritime Autonomy and Remote Navigation 2023

A Review of USVs for the Royal Australian Navy

Sam De Vincentis [1*], Nirman Jayarathne[1], Luke Baxter[1], and
Lachlan Stammers[1]
[1] Navantia Australia, Australia
`svincentis@navantia.com.au`

Abstract

Uncrewed Surface Vessels (USV) have been gaining increasing attention from navies due to their potential to revolutionize maritime operations. USVs can be integrated into naval fleets and tasked to perform essential and dangerous missions, minimizing the requirement for humans to be physically present. In addition, USVs help enhance situational awareness, provide greater surveillance capabilities, and can operate for extended periods at sea, which are vital in modern maritime security operations. This paper reviews the current state of USV technology and its potential applications in the Australian naval fleet. A detailed review of USVs that are currently being developed for navies, the functions they are fulfilling, and the available control systems employed to operate them are discussed in this paper. As USVs become more prevalent, it is essential to address the challenges associated with their deployment. Thus, the paper includes a review of the Australian legal and regulatory frameworks required to ensure their safe and secure operation and how these regulations are being developed by stakeholder engagement. In addition, the paper discusses the challenges the Australian government would face in the process of future research and development of advanced uncrewed vessel systems.

Keywords: USV, Regulations, RAN, Technology

1 Introduction

The Royal Australian Navy (RAN) has identified that unmanned/uninhabited systems will play a key role in shaping the maritime capabilities of the future, with the most telling evidence of this strategic direction being the release of the Robotics, Autonomous Systems and Artificial Intelligence (RAS-AI) Strategy 2040 (Royal Australian Navy, 2020). The RAS-AI Strategy 2040 was released in 2020 and

---

[*] Corresponding author

outlines the vision and capabilities that are available now, as well as those expected to mature in the near and far-term.

In the maritime context, the RAN has focused their RAS-AI capability predictions on three categories of unmanned systems: unmanned aerial vehicles (UAVs), unmanned surface vessels (USVs) and unmanned underwater vehicles (UUVs). The focus of this paper will be further exploration in the USV environment and how these vessels could become an integral component of the fleet within the next decade.

The applications of USVs in the maritime domain are seemingly endless, and it is no surprise that the USV industry is experiencing unprecedented levels of investment. In 2022 the USV market was estimated to be worth AUD $1.2 billion and is projected to reach AUD $3.29 billion by 2030 (VMR, 2023).

In terms of the role of USVs within the Australian Defence Force (ADF), there are a handful of applications where efforts and investment have been directed in recent years including Intelligence, Surveillance, and Reconnaissance (ISR), border and littoral zone patrol, Mine Countermeasures (MCM), Force Protection (FP), Anti-submarine Warfare (ASW), Electronic Warfare (EW) logistics, force projection and multi-role vessels.

The RAN is at an important junction in their USV journey. Currently there is both capital budgetary pressure (Uren, 2023) with several major naval acquisition programs currently underway, as well as rising workforce pressures attempting to keep pace with current and forecasted crewing requirements (Australia Government (Defence), 2022a). USVs will play a pivotal role in the naval fleets of the future, however it is critical that future investment in USVs targets the applications and missions most relevant to the RAN's needs. If executed wisely, the benefits of future RAN USV platforms could be immense, enabling a safer and more effective naval capability.

2 Global USV Usage

A desktop study was completed in this study, which compiled publicly available vessel data of USVs. As a starting point, this review considered USVs located all over the world from a variety of industry sectors including Defence (DEF), Commercial (COM), Science (SCI) and Emergency Service Agencies (ESA). This study comprised of a total of 150 USVs and a breakdown of them by industry is provided in Figure 1. As can be in seen in Figure 1, commercial industry has the largest market share (49%), closely followed by Defence 44% with Science and Emergency Services sectors comprising the remaining 7%.

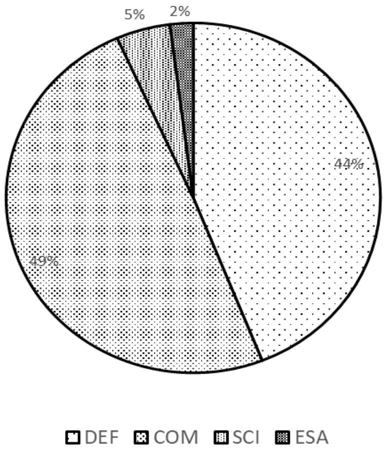

Figure 1: USV distribution by industry

3 Discussion

3.1 Current Review of USV Technology and Application

The current level of maturity of USV technologies allows USVs, either in active service or for test and training purposes, to perform a wide range of missions. As the technology advances, the argument for the advantages and efficiencies that USVs can deliver will only grow stronger. There are several roles and mission scenarios to analyse the advantages and disadvantages of each specific use-case, however the below mission scenarios have been highlighted to provide some insights to the benefits and trade-offs associated with USVs, as well as comparisons with their manned counterparts:

1. Intelligence, Surveillance & Reconnaissance
2. Antisubmarine Warfare
3. Training Platform

3.1.1. Intelligence, Surveillance & Reconnaissance (ISR)

An ISR mission which has already proven popular for USV development is data collection in a permissive environment. For this type of mission, a USV's potential persistence and ability to be deployed for long periods of time without re-supply is a distinct advantage over comparably sized manned platforms (Savitz, et al., 2013). Essentially the longer the USV can be deployed, the more data that can be collected, and unlike UUVs and AUVs, USVs are able to collect data both above and below the waterline. When considering ISR missions in hostile environments, USVs have the major advantage of keeping personnel and valuable manned platforms out of dangerous environments (Xie, et al., 2020).

Whilst operational persistence and flexible data collection are obvious strong suits of ISR USVs, the main disadvantage when compared to manned counterparts is the ability to process the collected data. A manned platform might have personnel who are able to process the data immediately, whereas an unmanned platform would need to relay information to a second site for analysis (Savitz, et al., 2013).

3.1.2. Antisubmarine Warfare (ASW)

One example of an ASW mission is unarmed area sanitisation where the objective is to warn or assure that no enemy submarine is operating in a designated area. Traditionally this type of mission is conducted by multi-mission manned platforms (surface ships, submarines, or aircraft), and consequently unarmed ASW area sanitisation is often a resource intensive and thus expensive operation. Cost savings and freeing up manned platforms to perform other missions are therefore the main advantages of using USVs for ASW area sanitisation (Unlu, 2015).

Unarmed ASW area sanitisation operations in peacetime setting has been judged as generally more acceptable than in a conflict scenario. The use of USVs to fulfill this mission in wartime could be unacceptable because the survival of personnel and high value assets would depend critically on the onboard processing and autonomy capabilities of the USV to detect and classify elusive targets, without saturating communications links with processing demands or false alarms. The use of USVs for this type of mission would require very high confidence level in the reliability and dependability of USVs and their communications systems (Savitz, et al., 2013).

3.1.3. USVs as Test Platform

USVs can perform the role of a test platform in two ways; one (1) for equipment that will eventually be installed on surface ships and two (2) for testing USV equipment and systems and examining the suitability of USVs to perform different missions. One advantage of employing USVs as test platforms is that it allows new systems and equipment to be tested in their intended operational environment whilst reducing the burden on manned surface ships that currently act as test platforms. New systems and equipment do not always perform well when first installed, and an operational evaluation in a USV would provide a relatively low-cost opportunity to test the system's fitness for service (Savitz, et al., 2013).

USVs employed as test platforms can be operated in a benign environment and offers the opportunity to 'get the bugs out' without adding unnecessary burden on ship's crew. Surface ships already act as test platforms, USVs could perform this role at a lower cost than manned surface platforms, even if this is simply just from the perspective that USVs consume less fuel and/or other consumables compared to similarly sized manned variants (Savitz, et al., 2013).

The disadvantage of employing USVs as test platforms is the additional time and cost that may be required to conduct an operational evaluation on a USV, and the fact that a USV may not be the appropriate test platform for all systems and equipment (Savitz, et al., 2013).

3.2 Control Systems

Control Systems vary depending on the level of Contextual Autonomous Capability (CAC) required for USV operations. The three (3) categories of autonomy that encompass USVs are fully autonomous, semi-autonomous, and remote control.

Full autonomy can be achieved by incorporating control system packages which operate navigation, equipment/sensor operation, and data transfer. These USVs are typically run based on artificial intelligence (AI) and machine learning (ML) algorithms, which allow the USV to make intelligent decisions with minimal Human Robot Interface HRI.

An example of a USV capable of full autonomy is the Ocius Bluebottle. This is a small autonomous data gathering communications platform USV designed for hydrographic, environmental monitoring and maritime surveillance. The control system onboard is an AI and ML platform which controls navigation, sensor deployment and control, and data transfer back to a ground station at predetermined intervals for data processing (Ocius, 2023).

Semi-autonomous USVs have a moderate to low CAC level, normally influenced by the complexity of a task where there is limited understanding and response to environmental and operational conditions (Huang, Messian, & Albus, 2007). Mooring, vessel-to-vessel transfer/interaction, and congested waterways are some areas where HRI come into play.

One of the examples of integrating multiple capabilities is the Turkish Navy's ULAQ, which is a USV designed for AUSV, ASW, MCM, EW, FF, and ISR. The ULAQ can carry out predefined missions autonomously or monitored and controlled from a remote-control station. Given the typical mission profile for this USV, an HRI is required for safe operation, this is because the ULAQ is required with carrying out missions involving threat detection and elimination. In these situations, it is important to have a human operator who can make informed decisions on how to respond to a threat (Unmanned Systems Technology, 2022).

Remote controlled USVs do not require AI or ML systems to carry out their intended missions. One driving factor for a USV to be remote controlled is that the mission profile may only require the vessel to travel a short distance to achieve its goal, incorporating autonomy into the USV would far exceed the cost benefit of the platform.

Emily is a family of remote controlled USVs which are designed for SAR and Man Overboard (MOB) missions and is highly adept to operate in the marine environment. These USVs are designed to be simple to operate and fast to deploy in time sensitive situations. By eliminating sensors for autonomy, Emily is light and rugged making it suitable to deploy from any location.

3.3 Regulation and Legislation

Rules and Regulations that govern safe operations of traditionally manned vessels internationally will be applicable to USVs to both prevent loss of assets and in the event on an incident, provide clear direction on who the at fault party is. Below are some of the challenges and regulatory updates/advancements being undertaken by national and international regulatory authorities governing the safe operation of USVs.

Regulatory body, the Australia Maritime Safety Authority (AMSA), govern the rules and regulations that apply to autonomous vessels in Australia. Autonomous vessels are governed by domestic commercial vessels, regulated Australian vessels, and foreign vessels rules which is the same regulatory framework that govern all vessels operating in Australian waters. Given the challenges with applying existing regulations to new technology, AMSA can provide guidance on the regulatory requirement while the autonomous space continues to develop (Australian Maritime Safety Authority, 2022).

AMSA is working with stakeholders and industry groups to ensure the appropriate regulations are put in place. In 2019, AMSA hosted the Australian Autonomous Vessel Forum which included 135 industry, academic and government experts in automation and digitalisation to share their knowledge and experience on the growing autonomous maritime industry (Australian Maritime Safety Authority, 2019). The drive to update and create new regulations has continued with collaboration in succeeding Autonomous Vessel Forum, with the primary outcome being that industry, academic, government, and defence collaboration is required to develop new regulation for autonomous vessels as the current framework is not working (Trusted Autonomous Systems, 2022).

Convention on the International Regulations for Preventing Collisions at Sea (COLREGS) consist of 41 rules covering a range of topics including lights and shapes, sound signals and steering and sailing of vessels. COLREGS is binding to all vessels upon the high seas and all waters connected to the high seas and navigable by seagoing vessels. The inherent nature of the wording in COLREGS is humancentric. Wording such as “look-out by site” and “ordinary practice of seaman” is riddled throughout these regulations and other International Maritime Organization (IMO) publications (International Maritime Organization, 2003), but what does this mean for autonomous systems on vessels and who is at fault if a collision does occur? Simply, the AI and ML processes need to be able to determine which rule is most applicable to the current situation when there are conflicting rules and how to proceed when another vessel does not appear to be following said rules.

Trusted Autonomous Systems (TAS) Assurance of Autonomy have commenced a project known as “TAS COLREGs Project” where the project aims to identify specific risks posed to all levels of autonomous vessels. This gives flexibility in how the designers and operators comply with the enabling framework. The result of this framework is that designers and operators will have repeatable, scalable, and enable methodology that is underpinned by logical, reasoned, and justifiable by argument (Trusted Autonomous Systems, 2021).

One of the key strategic directions of IMO’s 2018-2023 strategic plan was to integrate new and advancing technologies into their regulatory framework. This meant weighing up the benefits of new and emerging technology against safety and security, environmental impact, the impact on international trade, potential cost to the industry, and the impact on personnel (International Maritime Organization, 2023). The goal of this exercise is to devolope a regulatory framework name Maritime Autonomous Surface Ships (MASS). MASS is intended to be a voluntary goal based code to take effect in 2025 with the objective to regulate the operation of USVs, this will form the basis for mandatory regulations to come into effect in 2028 (International Maritime Organization, 2022).

4 Conclusion

RAN has an obvious need for vessels designed to reduce the manpower of personnel, with their permanent members remaining relatively unchanged in the past calendar year, especially if their goal is to grow their surface fleet. USVs are the clear path to achieving this; with the ability to perform ISR missions indefinitely, keep crew safe and reduce costs associated with MCM and ASW operations, and to test new technology on modular platforms.

Control systems on USVs vary depending on mission profile and to what level humans can be removed from missions. Reducing the risk to human life and an increasing pressure on permanent members of RAN are driving factors to adopt USVs into the current fleet which will allow humans to focus their decision making on areas which cannot yet be performed by AI and ML processes.

The future of rules and regulations that govern USVs is underdevelopment and will undoubtedly continue to evolve in the coming years with MASS coming into voluntary effect in 2025. A flexible and future proof framework is required to address the issues of ambiguity of the current rule sets. For this, it is critical for stakeholder engagement so all areas of rules and regulations are addressed by the people who will need to enforce and apply them to future vessels.

There are many roles in RAN currently being performed by manned vessels which could be partially or entirely replaced by USVs. Beginning to adapt these vessels as soon as possible will smooth the transition from traditionally crewed vessels to USVs before the technology matures to the point where it is difficult to incorporate into day-to-day operations and see significant cost savings in the future. When the benefits of USVs are fully realised by RAN, the surface fleet will be a cohesive unit of crewed and uncrewed vessels supporting both Australia and our Indo-Pacific neighbours.

References

Australia Government (Defence. (2022a). Table C.11: Permanent ADF members by location, 2021-22. Retrieved from Transparency: https://www.transparency.gov.au/annual- reports/department-defence/reporting-year/2021-22-81

Australia Government (Defence). (2022b). Table C.12: Permanent Australian Defence Force members by location, 2020-21. Retrieved from Transparency:
https://www.transparency.gov.au/annual-reports/department-defence/reporting-year/2021- 22-82

Australian Maritime Safety Authority. (2019). Australian Autonomous Vessel Forum, Post-event Communique. Australian Maritime Safety Authority.

Australian Maritime Safety Authority. (2022, August). Autonomous vessels in Australia. Retrieved from Australian Maritime Safety Authority: https://www.amsa.gov.au/vessels- operators/domestic-commercial-vessels/autonomous-vessels-australia

Huang, H.-M., Messian, E., & Albus, J. (2007). Autonomy Levels for Unmanned Systems (ALFUS) Framework. In Volume II: Framework Models Version 1.0. National Insititute of Standards and Technology.

International Maritime Organization. (2003). COLREGS: Convention on the International Regulations for Preventing Collisions at Sea, 1972. London: International Maritime Organization.

International Maritime Organization. (2022, November). Maritime Safety Committee (MSC 106). Retrieved from International Maritime Organization:
https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/MSC-106.aspx

International Maritime Organization. (2023). Autonomous shipping. Retrieved from International Maritime Organization:
https://www.imo.org/en/MediaCentre/HotTopics/Pages/Autonomous-shipping.aspx

Ocius. (2023, July 24). Ocius Drones. Retrieved from Ocius: https://ocius.com.au/usv/ Royal Australian Navy. (2020). RAS-AI STRATEGY 2040. Australian Government.

Savitz, S., Blickstein, I., Buryk, P., Button, R., DeLuca, P., Dryden, J., . . . Yurchak, J. (2013). U.S. Navy Employment Options for Unmanned Surface Vehicles (USVs). Santa Monica, CA: RAND.

Trusted Autonomous Systems. (2021, August). Enabling COLREGs Compliance for Autonomous & Remotely Operated Vessels. Retrieved from Trusted Autonomous Systems: https://tasdcrc.com.au/enabling-colregs-compliance-for-autonomous-remotely-operated- vessels/

Trusted Autonomous Systems. (2022). Reflecting on the Autonomous Vessel Forum 2022. Retrieved from Trusted Autonomous Systems: https://tasdcrc.com.au/reflecting-on-the-autonomous-vessel-forum-2022/

Unlu, S. (2015). Effectiveness of unmanned surface vehicles in anti- submarine warfare with the goal of protecting a high value unit. Monterey, California: Naval Postgraduate School.

Unmanned Systems Technology. (2022). ULAQ Unmanned Surface Vehicle. Retrieved from Unmanned Systems Technology: https://www.unmannedsystemstechnology.com/company/meteksan-defense/ulaq-unmanned- surface-vehicle/

Uren, D. (2023, May 10). Budget reveals pressures on Defence for savings to fund nuclear-powered submarines. Retrieved from Australian Strategy Policy Insitute: https://www.aspistrategist.org.au/budget-reveals-pressures-on-defence-for-savings-to-fund- nuclear-powered-submarines/

VMR. (2023, May). Unmanned surface vehicle (USV) market size, share & forecast. Retrieved from Verified Market Research: https://www.verifiedmarketresearch.com/product/unmanned-surface-vehicle-usv- market/#:~:text=Unmanned%20Surface%20Vehicle%20(USV)%20Market%20size%

Xie, J., Luo, J., Peng, Y., Xie, S., Pu, H., Li, X., . . . Zhou, R. (2020). Data driven hybrid edge computing-based hierarchical task guidance for efficient maritime escorting with multiple unmanned surface vehicles. Peer-to-Peer Networking and Applications.