AUTONOMOUS AND REMOTELY OPERATED VESSELS: 2021 TO 2040

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Predictions for the Australian maritime industry in 2040:

1. Minimally crewed vessels with a spectrum of autonomous capabilities will be a normalised part of the commercial vessel fleet operating for routine passenger transport, movement of goods, scientific research, and tourism. The police, border protection and Defence agencies will have significant numbers of semi-autonomous and autonomous vessels in their fleets.
2. A Maritime Water Space Management System (MWSPS) will have been implemented to manage allocation of surface and sub-surface water space and interaction between smart vessels.
3. The deconfliction service offered through the MWSPS, together with advanced navigation, sensing, and inter-vessel communication technologies, will enable minimal-crewing, and multiple semi-or fully-autonomous vessels to be supervised remotely by single operators, due to the significant reduction in collision risk.
4. A new Commonwealth Government entity, 'Australian Complex Autonomous Systems Safety Authority' (ACASSA) will set the standards and conduct assurance activities for the "black box" behind autonomous and semi-autonomous systems, for each of the air, land and maritime domains. Two-way secondments between ACASSA and traditional regulators will ensure a seamless experience for stakeholders, consistent regulatory and policy development, and the upskilling of staff.
5. "RegTech" concepts will be implemented by the ACASSA to enable continuous background monitoring of AI-based autonomous systems, using risk thresholds to determine input required by the operator, and enabling non-intrusive compliance checks.
6. Australian Ports are able to accommodate large international trading vessels with advanced autonomy on board, and the integration of Vessel Traffic Services with the Maritime Water Space Management System have reduced the workload of VTS operators and vessel crew, reduced incidents, and improved efficiency.

"Autonomous shipping is the future of the maritime industry. As disruptive as the smart phone, the smart ship will revolutionise the landscape of ship design and operations".

***Mikael Mäkinen, President Rolls-Royce Marine*[1]**

"Remote and autonomous ships have the potential to redefine the maritime industry and the role of players in it with implications for shipping companies, shipbuilders, maritime systems providers and technology companies from other (especially the automotive) sectors."[2]

[1] Advanced Autonomous Waterborne Applications (AAWA initiative), Remote and Autonomous Ships: The Next Steps (accessed https://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/customers/marine/ship-intel/aawa-whitepaper-210616.pdf, 26 May 2021)

[2] Advanced Autonomous Waterborne Applications (AAWA initiative), Remote and Autonomous Ships: The Next Steps (accessed https://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/customers/marine/ship-intel/aawa-whitepaper-210616.pdf, 26 May 2021)

Introduction

Autonomous systems technology has the potential to revolutionise the Australian maritime industry, reducing risk, operational cost and environment impact, while increasing efficiency and reliability.

To be strong and sustainable in 2040, the maritime industry and Australian Government must work together to develop the knowledge, culture, and regulatory frameworks required to facilitate the uptake of this technology.

This will see uses flourish in a range of industries including hydrographic surveying, marine surveying, scientific research, oil and gas, transport and Defence. Failure to start enacting change now, in 2021, risks the opportunities on offer being monopolised by foreign companies into the future.

The Australian maritime industry already faces many hurdles – we must act to ensure autonomous systems technology is a leg up, not a missed opportunity.

Problem Statement

We know that autonomous systems technology will revolutionise the maritime industry, reducing risk[3], operational cost and environment impact, while increasing efficiency and reliability[4].

We know that there are strong use cases for this technology, currently in scientific research, hydrographic surveying, oil and gas, and Defence, and that in the future this will expand to tourism and transport of people and goods.

We know that countries such as Finland, Norway and the United Kingdom are making rapid advancements in both the technology and the regulatory approach, but that Australian capability is not developing at the same rate.

We also know that the current Australian regulatory framework is prescriptive, outdated, and not appropriate for autonomous technology – it assumes a human will be on board and in control, and when this is not the case, bespoke exemption processes are required. We know this is a resource burden on industry and on the regulator, the Australian Maritime Safety Authority (AMSA), and that only small steps have been taken to date to address this.

We also know that the regulatory issues are not just an AMSA problem. AMSA cannot amend its legislation, only the Department of Infrastructure, Transport, Regional Development and Communications[5] can lead that. Without legislative amendment, AMSA is forced to continue relying on exemptions, rather than being empowered to enact more appropriate regulatory approaches. Until AMSA's legislation is changed, no significant regulatory progress will be made.

The Australian maritime industry and the Australian Government know that autonomous technology is here, and that as its capacity and availability increases, so too will the number of organisations seeking to develop, sell and use them. What I know is that we need to work together to advocate for, and realise, the type of change necessary to realise the benefits we are all aware of, to ensure both current and

[3] "According to Allianz Global Corporate & Specialty, between 75% and 96% of all accidents in the shipping sector can be attributed to human error." Walker. Jon, Autonomous Ships Timeline – Comparing Rolls-Royce, Kongsberg, Yara and More, Emerj, 22 November 2019 (accessed https://emerj.com/ai-adoption-timelines/autonomous-ships-timeline/, 26 May 2021)

[4] Horne. R, Putland. T, Brady. M, 'Regulating Trusted Autonomous Systems in Australia' (Conference paper [in progress]), pg. 3

[5] AMSA's portfolio agency

future generations of Australians will benefit from this technology for years to come.

Whether the opportunity presented by this technology is captured by Australians, or monopolised by foreign entities, will depend on how ready the industry is to accept the change this technology brings, and how effectively the Australian Government can modernise its regulatory approach to facilitate development and uptake. In the age of COVID-19 and increasingly volatile global relations, Australia must build its sovereign capability, and be a technology leader, not a technology sceptic. The future of the Australian maritime industry and its workforce depends on it.

Background

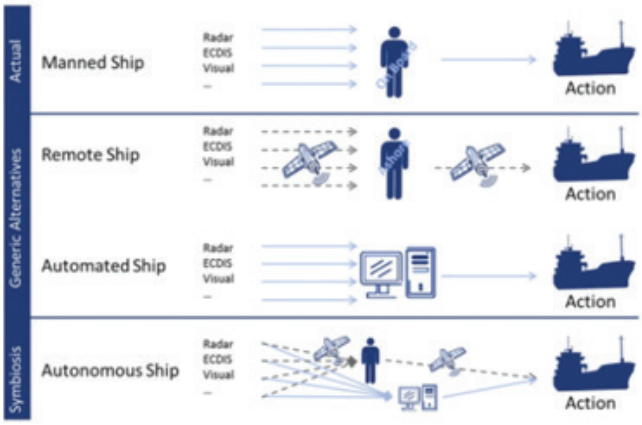
Autonomous Vessels

What are autonomous vessels?

Vessels capable of autonomous and remote operation, colloquially known as autonomous vessels (even though none are currently capable of 'true' autonomy), have been in commercial operation in Australia since approximately 2017. Hydrographic surveying and scientific research are the most common uses to date, with specialised vessels ranging from between less than 1 metre to 12 metres in length. Small autonomous underwater vessels (AUVs) have been used by the Australian scientific research community for a longer period of time than indicated above.

There is a variety of terminology available to describe autonomous vessels, and domains or industries often have their own internal preferences. For example, Autonomous Surface Vessel (ASV) or Autonomous Underwater Vessel (AUV) is common within scientific research, whereas Unmanned Surface Vessel (USV) or Unmanned Underwater Vessel (UUV) are more common in the Navy. The term Remotely Operated Vessel (ROV) refers specifically to tethered vessels, which are generally small, sub-surface, and are commonly used in the oil and gas industry. The term 'Maritime Autonomous Surface Ship' (MASS) is used by the International Maritime Organization (IMO), and refers to large seagoing vessels, for example cargo ships, in contrast to the much smaller vessels operating domestically.

The actual term 'autonomous vessel' covers a wide variety of possible technologies, with remote operation the common factor, and a spectrum of autonomous behaviours and support functions available.[6] For example:[7]



The Autonomous Ship, as it is understood in the MUNIN project, is a symbiosis of the Remote Ship and the Automatic Ship – © MUNIN

The specific technologies that enable autonomous and remotely operated vessels include a combination of sensors, decision support and control systems based on algorithms, communication systems, and internet connectivity.

[6] World Maritime University, Transport 2040: Autonomous ships: A new paradigm for Norwegian shipping – Technology and transformation, 2019 (accessed https://commons.wmu.se/cgi/viewcontent.cgi?article=1072&context=lib_reports)

[7] Unmanned Ship Org, Munin, The Autonomous Ship (http://www.unmanned-ship.org/munin/about/the-autonomus-ship/, accessed 26 May 21)

Some examples of autonomous vessels operating in Australia include:

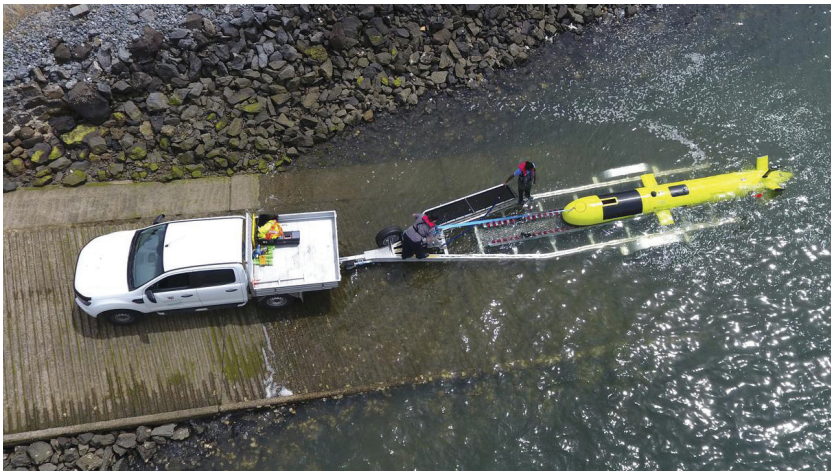


Image of Explorer AUV, used with permission from Damien Guihen

Image of Iver AUV, used with permission from L3Harris

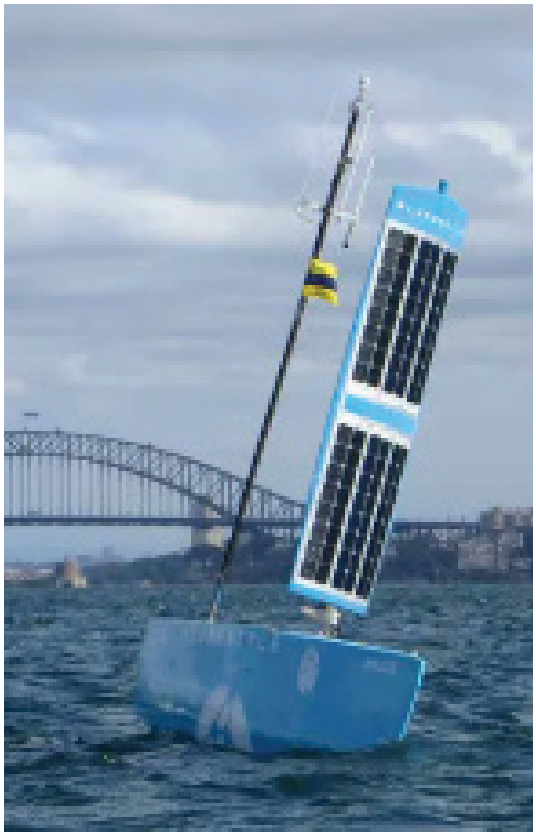


Image of Ocius Bluebottle, used with permission from Ocius

Image of Coral AUV, used with permission from AIMS

Image of Fugro Seakit, used with permission from Fugro

Why are autonomous vessels so beneficial for the maritime industry?

Autonomous vessels present significant opportunity to reduce maritime incidents, injuries and fatalities. The European Maritime Safety Agency accident statistics between 2011 and 2016 identified human error as being "… the triggering factor in 62 per cent of incidents with EU registered ships from 2011 to 2016… Statistics on fatal accidents have ascertained that work on deck, for example mooring operations, is 5 to 16 times more dangerous than jobs ashore…"[8] Removing workers from dull, dirty and dangerous tasks can be achieved using autonomous technology.

In addition to the safety benefits, "two of the primary drivers for use of autonomous systems in the maritime domain are the efficiency and cost-saving benefits that can be realised. For example, in the hydrographic survey industry, opportunities were identified early on to save a significant portion of fuel budgets by using small autonomous vessels to conduct the majority of surveying work. This economic incentive, which extends from fuel savings into the opportunity for concurrent operations without additional crew costs, and longer operation times, has driven the development of increasingly sophisticated autonomous vessels. In addition to economic incentives, autonomous systems have the capacity to…reduce the environmental impact of commercial activities."[9]

What will we see in autonomous vessels by 2040?

"Networks of autonomous surface and underwater vessels are set to radically change the nature of maritime operations, says Tim Kent, Technical Director, Marine and Offshore, Lloyd's Register."[10]

"Unmanned ships will be more efficient, reduce emissions and operate at lower cost, but this will require effective integration of sensors with improved decision-making algorithms. Autonomous vessels feature similar technology to self-driving cars and use a range of physical sensors to power autonomous functions, including: Global Positioning System (GPS), Inertial Navigation System (INS), optical and infra-red cameras, radar, lidar (light detection and ranging), high-resolution sonar, microphones, and wind and pressure sensors."[11]

"Applied artificial intelligence, low cost low size sensors, increased connectivity, improved cyber security and better energy management are all likely to drive rapid and disruptive change in the maritime industry."[12]

"A ship's ability to monitor its own health, establish and communicate what is around it and make decisions based on that information is vital to the development of autonomous operations."[13]

[8] Technical University of Denmark, A Pre-analysis on Autonomous Ships, 2017 (accessed https://www.dma.dk/Documents/Publikationer/Autonome%20skibe_DTU_rapport_UK.pdf, 26 May 2021)

[9] Horne. R, Putland. T, Brady. M, 'Regulating Trusted Autonomous Systems in Australia' (Conference paper [in progress]).

[10] The Maritime Executive, 'Autonomous ships before autonomous cars?', 12 September 2017 (https://www.maritime-executive.com/article/autonomous-ships-before-autonomous-cars, accessed 26 May 2021)

[11] Ibid.,

[12] Ibid.,

[13] Rolls-Royce, Ship Intelligence: Marine, Autonomous Ships – The next step, 2016 (https://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/%20customers/marine/ship-intel/rr-ship-intel-aawa-8pg.pdf, accessed 26 May 2021)

Image from Ship Intelligence: Marine, Autonomous Ships – The next step, Rolls-Royce 2016[14]

The technological advancements that will contribute to this vision are: sensor fusion; control algorithms; and communication and connectivity, enabled by reliable internet/satellite connection and cyber security.[15] Increasingly advanced adaptive mission planning capabilities will also play an important role. These advancements will continue to improve the safety and efficiency of maritime operations, opening new opportunities to monetise and improve the movement of people and goods, and to provide services for the community.

AMSA's Corporate Plan 2020/21 offered a reminder that, "While technology can improve safety, efficiency and environmental protection, it comes with new safety, security and environmental risks that must be properly understood and managed."[16]

What about Defence?

Defence is investing heavily in trusted autonomous systems across the Airforce, Army and Navy, with a focus on building Australian sovereign capability. In a maritime context, the Navy has been working alongside industry for a number of years to support the development of important autonomous capability, in both surface and sub-surface environments. In the recently released Navy RAS-AI Strategy 2040, the Chief of Navy, Vice Admiral Michael Noonan, AO, RAN, said:

"To fulfil our potential, we need to engage in constant experimentation, and encourage collaboration and innovation at all levels. This will enable us to leverage RAS-AI [Robotics, Autonomous Systems and Artificial Intelligence] to enhance Navy's capability by strengthening our Force Protection, increasing our Force Projection in the maritime approaches of our near region, improving our Joint Integration through Partnership, maximising our Force Potential, and ensuring Australian Control."[17]

The Strategy outlines common trends across technologies that enable effective RAS-AI systems, the common enablers, important advances that will need to be made, and the potential technologies that could be in place by 2040. While some vessel-specific

[14] Ibid.,

[15] Ibid.,

[16] Australian Maritime Safety Authority, 2020/21 Corporate Plan (accessed https://www.amsa.gov.au/sites/default/files/corporate-plan-2020-21.pdf, 26 May 2021)

[17] Royal Australian Navy, Warfare Innovation Navy, RAS-AI Strategy 2040 (https://www.navy.gov.au/sites/default/files/documents/RAN_WIN_RASAI_Strategy_2040f2_hi.pdf, accessed 26 May 2021)

elements such as propulsion, power, reduced maintenance requirements, and launch and recovery systems are mentioned, the focus is on the 'smarts', i.e. systems of control, teaming and swarming, means and modes of communicating, and AI, all of which require big data access, secure computing, and trusted and dynamic spectrum management. The 2040 technology discussion focussed on cognitive capabilities such as scene understanding, abstraction, ideas-based reasoning, coordinated swarms, and understanding of intent. There was also mention of on-board data processing, autonomous cyber-defence, and self-healing mesh networking paths.[18]

Defence is facilitating the development of autonomous technologies through a range of initiatives, including Defence Innovation Hub grants, the Defence AI Centre, and through investment into the Trusted Autonomous Systems Defence Cooperative Research Centre (TAS). TAS was established under the Next Generation Technologies Fund to facilitate game changing Defence technology projects. TAS is also working to facilitate and accelerate understanding and resources related to the ethics and law of trusted autonomous systems, and the assurance of autonomy. TAS projects funded by the Queensland Government are delivering tools and resources to support Australian industry, and improve the assurance and accreditation framework in Australia. The multidisciplinary approach championed by TAS, which sees industry, academia and Defence work together, is particularly effective in autonomous systems developments.

Impact on workforce

"Automation and other technological changes are emerging and are expected to significantly impact on the workforce. While automation may reduce the need for some occupations, it will also require the development of new specialist skills to operate, manage and maintain the machines."[19]

"As vessels become remotely operated, it is expected that the workforce will increasingly be working in onshore operation centres rather than at sea."[20]

"Key trends in the maritime and ports workforce include:

1. Ageing workforce

2. Technological change

3. Skills shortages and competition

4. Lack of available training berths

5. A decline in resources freight but growth in cruises and containers."[21]

Increasing use of autonomous and remotely operated vessels in Australia will impact the maritime workforce. While some current roles may not exist in the same way by 2040, there will remain a strong demand for seafarers with the experience to operate and supervise these vessels, and for engineers and other technical roles to build and maintain them. The 2021 workforce is not sufficient to meet the demands of the maritime industry; the Maritime IRC's 2019 Skills Forecast identified that over 78% of employers reported experiencing a skills shortage during the last

[18] Royal Australian Navy, Warfare Innovation Navy, RAS-AI Strategy 2040 (https://www.navy.gov.au/sites/default/files/documents/RAN_WIN_RASAI_Strategy_2040f2_hi.pdf, accessed 26 May 2021)

[19] State of Queensland (Department of Transport and Main Roads), Queensland Transport and Logistics Workforce: Current and Future Trends Report, November 2018 (accessed 27 May 2021)

[20] State of Queensland (Department of Transport and Main Roads), Queensland Transport and Logistics Workforce: Current and Future Trends Report, November 2018 (accessed 27 May 2021)

[21] Ibid.,

12 months, including for small vessel (<35m) masters, engineers, marine engine drivers, deckhands, and navigation.[22]

The report identified a number of causes for the shortage, including ageing workforce, salaries considered too low, competition, and the geographic location of the role.[23] These issues must be addressed, and the workforce upskilled and strengthened, in preparation for the requirements this new technology will impose, and to ensure the demand is filled using Australian expertise.

The Maritime IRC's 2020 Skills Forecast (abridged annual update) identified that the workforce needs to be upskilled as a priority, noting the changes to operations caused by e-navigation, autonomous berthing and unberthing, remote monitoring and auto-collision technologies, and the new skills that autonomous vessels and dynamic positioning will require.[24] This training will need to occur through new training programs, which AMC Search in Tasmania is currently leading the charge on. However, while there is no dedicated qualification framework for autonomous and remotely operated vessels, it will remain an uncertain and largely untapped area of potential.

Regulation of Autonomous Vessels

How are autonomous vessels regulated?

Autonomous and remotely operated vessels are regulated by the Australian Maritime Safety Authority (AMSA), which is the Commonwealth statutory authority responsible for maritime safety, protection of the marine environment from pollution, and search and rescue.[25]

Vessels are categorised as either domestic commercial vessels under the *Marine Safety* (Domestic Commercial Vessel) *National Law Act 2012* (National Law Act) or regulated Australian vessels under the *Navigation Act 2012* (Navigation Act). Vessels need to have the requisite certification, which requires complying with specific survey standards and operational requirements.

"The laws, Marine Orders, and standards that apply to all commercial vessels were written for traditional manned vessels, but remotely operated and autonomous vessels must also comply with them. As the unmanned vessels generally cannot comply with the design, construction, equipping and survey requirements applied to traditional vessels, and there are no tailored standards available to use, operators must seek exemptions in order to operate. This reliance on exemptions may not be feasible beyond the short term, due to the administrative burden and delays it creates for operators and AMSA."[26]

AMSA's legislation is somewhat rigid, which is what causes the reliance on exemptions. Until the legislation is changed, AMSA is limited to regulatory action such as issuing guidance, setting policy, upskilling AMSA officers, and providing information to industry. AMSA also established a relationship in 2019 with the Trusted Autonomous Systems Defence

[22] Australian Industry Standards, Maritime Skills Forecast 2019 (accessed https://www.australianindustrystandards.org.au/wp-content/uploads/2020/08/MAR-SF-FULL-2019.pdf, 27 May 2021)

[23] Ibid.,

[24] Ibid.,

[25] G Judson and R Horne, 'The regulatory approach for vessels capable of autonomous and remote-controlled operation' (Conference paper, International Maritime Conference, Pacific 2019).

[26] G Judson and R Horne, 'The regulatory approach for vessels capable of autonomous and remote-controlled operation' (Conference paper, International Maritime Conference, Pacific 2019).

Cooperative Research Centre (TASD CRC) to explore issues around assurance and trust in autonomous systems.

What is conceptually hard about regulating these vessels?

"There are many challenges associated with effectively regulating autonomous systems, including how to ensure trust in these systems, how to ensure the regulatory approach is the most appropriate option, how to adapt current systems safety approaches, and how to adapt current assurance and accreditation frameworks. The complex, interconnected nature of autonomous systems, including cybernetic systems, means that assurance as a concept must shift to account for the high levels of interdependency between core systems.[27]

For example, in an autonomous system some of the components that will require assurance include algorithms, software, hardware components, and the integrated robotic systems.[28]

The algorithms that underpin autonomous systems do not fit a traditional regulatory model because they are not static – they "… can be designed to constantly update based on new data (through machine learning). If a regulatory agency approves the use of a particular autonomous technology, the underlying code may evolve over time and become entirely different to the initially approved code (OECD 2019). Code is also often created in environments that are not open to scrutiny and, over time, algorithms may become increasingly complex, preventing regulatory agencies (and the wider population) from assessing their function (OECD 2019). It may be difficult to predict how a machine learning algorithm will respond to a new environment, or to data in a form it did not encounter during development or testing. These issues pose a challenge to both manufacturers and regulators."[29]

"While the regulation of automated technology is in its early days, tensions are already emerging between traditional public governance structures and the code-based decision making processes of automated technology (OECD 2019). Governments need to ensure regulatory frameworks are designed to ensure safety without imposing unnecessary regulatory burden or stifling productivity- and safety-enhancing innovation."[30]

Solutions

The technological developments that must happen to enable transition from the 2021 situation to the 2040 vision are well known, and numerous Australian organisations are investing in leading that work. Defence support for developing Australian sovereign capability will also accelerate progress. The harder challenge is to identify and enact the regulatory change which is required to reach that 2040 vision.

[27] Horne. R, Putland. T, Brady. M, 'Regulating Trusted Autonomous Systems in Australia' (Conference paper [in progress]).

[28] Devitt, K., Horne, R., Assaad, Z., Broad, E., Kurniawati, H., Cardier, B., Scott, A., Lazar, S., Gould, M., Adamson, C., Karl, C., Schrever, F., Keay, S., Tranter, K., Shellshear, E., Hunter, D., Brady, M., & Putland, T. (2021). Trust & Safety. Robotics Roadmap for Australia V.2 [forthcoming]. Robotics Australia Network.

[29] National Productivity Commission, National Transport Regulatory Reform: Productivity Commission Inquiry Report, No. 94, 7 April 2020 (accessed https://www.pc.gov.au/inquiries/completed/transport/report/transport.pdf, 26 May 2021)

[30] Ibid.,

The current approach, whereby traditional regulators are responsible for regulating increasingly complex autonomous technology, is not feasible longer term. A failure to change approach will compromise the Australian maritime industry's ability to develop and use this technology, and will force already resource-strapped regulators to make safety-related decisions without a sufficient understanding of the technology, its risks and mitigations, and without being able to provide guidance, confidence and certainty to industry and other waterways users.

Attention must also be given to supporting the maritime workforce through the transition to autonomous and remotely operated vessels, to implementing an appropriate qualifications framework, and ensuring there are high quality, accessible, training providers with suitable offerings. The ageing, depleted workforce of 2021 will not be able to service the vision of 2040. The Government must act to support the current workforce, and to grow it to ensure all required skillsets are available domestically, to ensure it is Australians at the helm (or keyboard) of these vessels into the future.

A new regulator for autonomous systems

A new Commonwealth Government entity must be set up; the 'Australian Complex Autonomous Systems Safety Authority' (ACASSA) for example, with the mandate of setting the standards, regulating, and conducting assurance activities for the "black box" behind autonomous and semi-autonomous systems, across the air, land and maritime domains. This approach enables a consolidation of expertise regarding safety and assurance of autonomous systems, while traditional regulators continue regulating the actual physical aircraft, vehicles and vessels, operations, and traditional operators. This enables national consistency, and ensures innovation and opportunity across all three domains is facilitated through tailored regulation and access to significant expertise within Government. ACASSA should also be the Australian representative for international bodies and other international and Australian engagement on autonomous systems regulation.

ACASSA must implement "RegTech" concepts to enable continuous background monitoring of AI-based autonomous systems, using risk thresholds to determine input required by the operator, and enabling non-intrusive compliance checks.[31] ACASSA will set the minimum standard that autonomous systems must reach and maintain to meet Australia's expectations for safe operations in the marine environment.

ACASSA must also review and, where appropriate, implement the recommendations of leading bodies in the regulatory and assurance space.

For example, in 2019 a report by the Organisation for Economic Co-operation and Development recommended that "as a first step, regulators should identify the risks posed by the use of algorithms in transport technologies, and should employ staff who possess the relevant skills to enable the assessment of algorithms and autonomous

[31] Butler. R, O'Brien. L, (2019) Understanding RegTech for Digital Regulatory Compliance. In: Lynn T., Mooney J., Rosati P., Cummins M. (eds) Disrupting Finance. Palgrave Studies in Digital Business & Enabling Technologies. Palgrave Pivot, Cham. (accessed https://link.springer.com/content/pdf/10.1007%2F978-3-030-02330-0_6.pdf, 27 May 2021)

transport systems."[32] Whether Government agencies are actually able to employ suitably experienced and qualified people in a niche, quickly changing field, where there is strong private sector demand, is a separate question.

This new regulator will need to grapple with a range of unanswered questions, including:

- How current and future Work, Health and Safety requirements apply to staff in a shore-based control centre operating one or more remotely operated vessels or supervising autonomous vessels[33];
- Whether current insurance rules and policies are workable, or if the insurance industry needs support to adopt an improved approach that facilitates rather than impedes technology use;
- Where liability for incidents[34], and in circumstances where provisions in applicable legislation are breached, should sit;
- What should cyber-security requirements be, and how can they effectively support industry to avoid, respond to, and recover from threats and attacks;
- Data management, noting the huge volumes of data this technology will generate;
- Identifying and addressing privacy concerns;
- Identifying appropriate methods and requirements to test and trial autonomous systems, that properly match the risk of an operation with the level of assurance activity required;
- What skills and qualifications should operators of remotely operated vessels, and supervisors of autonomous vessels, hold;
- What "competencies" and "authorisations" should the remotely operated and autonomous vessel's 'system' hold;
- What is the best way to regulate emerging technology in Australia;
- How will autonomous platforms impact or challenge the ethics underpinning the fishing (including shellfish collection) industry; and
- What role will autonomous systems have in emergency distress calls and providing support to other vessels, for example with reference to SOLAS obligations?

It will be critical to ensure collaboration and communication between ACASSA and traditional regulators. Two-way secondments between the parties should be introduced in order to ensure a seamless experience for stakeholders, consistent regulatory and policy development, and the upskilling of staff.

A Clear Government Mandate Supporting the Development and use of Autonomous Systems

The Commonwealth Government must provide a mandate to Government agencies and private industry to facilitate the development and use of autonomous systems. This mandate will clarify the Government's proactive support for this technology, and

[32] National Productivity Commission, National Transport Regulatory Reform: Productivity Commission Inquiry Report, No. 94, 7 April 2020 (accessed https://www.pc.gov.au/inquiries/completed/transport/report/transport.pdf, 26 May 2021)

[33] The way WHS is managed in Air Traffic Control Centres should be investigated, to see if there are lessons that can be learned for shore-based control centres

[34] Advanced Autonomous Waterborne Applications (AAWA initiative), Remote and Autonomous Ships: The Next Steps (accessed https://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/customers/marine/ship-intel/aawa-whitepaper-210616.pdf, 26 May 2021)

help organisations properly resource the development and change necessary.

An example of where this mandate is needed is Australian ports. In order to receive business from autonomous vessels in the future, ports must have the necessary facilities, systems and technology in place. The upgrade process should already be underway, to ensure that early-technology demonstrator projects, for example the collaboration between Kongsberg and Yara on the Yara Birkeland, an electric autonomous shipping container vessel,[35] can be received in Australia, and to encourage other operators to bring their vessels, and accompanying economic activity, to our shores.

Conclusion

Autonomous and remotely operated vessels are already in operation in Australia and around the world, and their capability and availability are rapidly growing. It is predicted that, by 2040, these vessels will be an integrated, integral part of the Australian maritime industry, leading to safer, more efficient, maritime operations, with less environmental impact. However, to achieve that vision, significant effort from Government, the maritime industry, and other stakeholders must be invested to put in place the regulatory frameworks, qualifications frameworks, skills base, and port facilities, that are required.

Transitioning from 2021 to the vision for 2040 will require the following advancements:

Image created by Rachel Horne, June 2021

[35] Kongsberg, Autonomous Ship Project, Key Facts about Yarra Birkeland (accessed 21 June 21, https://www.kongsberg.com/maritime/support/themes/autonomous-ship-project-key-facts-about-yara-birkeland/)

These advancements are within Australia's reach, if a proactive, coordinated effort, led by Government, and incorporating industry and the community is enacted. If this effort is not put in now, for example because of distrust for new technology, fear about the impact on jobs, an inability to depart from 'the way it has always been done', or simply disinterest from the Australian Government, other countries, particularly those with more developed technological capability, will seize the advantage, and monopolise the opportunities on the table. Leveraging Australia's talented technologists and innovators, maintaining a strong focus on building sovereign capability through multi-disciplinary activities, and a Government-led, multi-domain effort to revamp Australia's regulatory approach to emerging technology, will position the Australian maritime industry to take full advantage of the spectrum of safety, environment, efficiency, and economic benefits of autonomous systems technology.

"Autonomous shipping must become culturally recognised, and it needs to become an appropriate norm in the industry. Such changes in mind-sets do not happen overnight, but there is indication that change is taking place as attention and wider public discussion around autonomous shipping is increasingly on the rise."[36]

"In other words, to fully realise the potential of autonomous shipping, the developed technologies must be deemed valuable by the wider marine industry as well as the society as a whole."[37]

[36] Technical University of Denmark, A Pre-analysis on Autonomous Ships, 2017 (accessed https://www.dma.dk/Documents/Publikationer/Autonome%20skibe_DTU_rapport_UK.pdf, 26 May 2021)

[37] Advanced Autonomous Waterborne Applications (AAWA initiative), Remote and Autonomous Ships: The Next Steps (accessed https://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/customers/marine/ship-intel/aawa-whitepaper-210616.pdf, 26 May 2021)

REFERENCES

Advanced Autonomous Waterborne Applications (AAWA initiative), Remote and Autonomous Ships: The Next Steps (accessed https://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/customers/marine/ship-intel/aawa-whitepaper-210616.pdf, 26 May 2021)

Airservices Australia, Future Airspace Management (accessed https://www.airservicesaustralia.com/about-us/innovation-and-technology/future-airspace-management/, 26 May 2021)

Australian Industry Standards, Maritime Skills Forecast 2019 (accessed https://www.australianindustrystandards.org.au/wp-content/uploads/2020/08/MAR-SF-FULL-2019.pdf, 27 May 2021)

Australian Maritime Safety Authority, 2020/21 Corporate Plan (accessed https://www.amsa.gov.au/sites/default/files/corporate-plan-2020-21.pdf, 26 May 2021)

Australian Maritime Safety Authority, AMSA Response to National Productivity Commission enquiry into National Transport Regulatory Reform (2019)

Australian Maritime Safety Authority, Looking ahead—AMSA's operating environment 2017-2027 (accessed https://www.amsa.gov.au/sites/default/files/looking-ahead-2017-2027.pdf, 26 May 2021)

Australian Industry and Skills Committee, National Industry Insights: Maritime (accessed https://nationalindustryinsights.aisc.net.au/industries/transport/maritime, 26 May 2021)

Butler. R, O'Brien. L, (2019) Understanding RegTech for Digital Regulatory Compliance. In: Lynn T., Mooney J., Rosati P., Cummins M. (eds) Disrupting Finance. Palgrave Studies in Digital Business & Enabling Technologies. Palgrave Pivot, Cham. (accessed https://link.springer.com/content/pdf/10.1007%2F978-3-030-02330-0_6.pdf, 27 May 2021)

Devitt, K., Horne, R., Assaad, Z., Broad, E., Kurniawati, H., Cardier, B., Scott, A., Lazar, S., Gould, M., Adamson, C., Karl, C., Schrever, F., Keay, S., Tranter, K., Shellshear, E., Hunter, D., Brady, M., & Putland, T. (2021). Trust & Safety. Robotics Roadmap for Australia V.2 [forthcoming]. Robotics Australia Network.

Judson. G and Horne. R, 'The regulatory approach for vessels capable of autonomous and remote-controlled operation' (Conference paper, International Maritime Conference, Pacific 2019).

Horne. R, Putland. T, Brady. M, 'Regulating Trusted Autonomous Systems in Australia' (Conference paper [in progress]).

Kongsberg, Autonomous Ship Project, Key Facts about Yarra Birkeland (accessed 21 June 21, https://www.kongsberg.com/maritime/support/themes/autonomous-ship-project-key-facts-about-yara-birkeland/)

National Productivity Commission, National Transport Regulatory Reform: Productivity Commission Inquiry Report, No. 94, 7 April 2020 (accessed https://www.pc.gov.au/inquiries/completed/transport/report/transport.pdf, 26 May 2021)

Rolls-Royce, Ship Intelligence: Marine, Autonomous Ships – The next step, 2016 (https://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/%20customers/marine/ship-intel/rr-ship-intel-aawa-8pg.pdf, accessed 26 May 2021)

Royal Australian Navy, Warfare Innovation Navy, RAS-AI Strategy 2040 (https://www.navy.gov.au/sites/default/files/documents/RAN_WIN_RASAI_Strategy_2040f2_hi.pdf, accessed 26 May 2021)

State of Queensland (Department of Transport and Main Roads), Queensland Transport and Logistics Workforce: Current and Future Trends Report, November 2018

Technical University of Denmark, A Pre-analysis on Autonomous Ships, 2017 (accessed https://www.dma.dk/Documents/Publikationer/Autonome%20skibe_DTU_rapport_UK.pdf, 26 May 2021)

The Maritime Executive, 'Autonomous ships before autonomous cars?', 12 September 2017 (https://www.maritime-executive.com/article/autonomous-ships-before-autonomous-cars, accessed 26 May 2021)

Unmanned Ship Org, Munin, The Autonomous Ship (http://www.unmanned-ship.org/munin/about/the-autonomus-ship/, accessed 26 May 21)

Walker. Jon, Autonomous Ships Timeline – Comparing Rolls-Royce, Kongsberg, Yara and More, Emerj, 22 November 2019 (accessed https://emerj.com/ai-adoption-timelines/autonomous-ships-timeline/, 26 May 2021)

World Maritime University, Transport 2040: Autonomous ships: A new paradigm for Norwegian shipping – Technology and transformation, 2019 (accessed https://commons.wmu.se/cgi/viewcontent.cgi?article=1072&context=lib_reports)