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Autonomous Vessels: How an Emerging Disruptive Technology Is Poised to Impact the Maritime Industry Much Sooner Than Anticipated

Sean T. Pribyl and Alan M. Weigel*

Automated vessel technology is rapidly transiting from the theoretical to the practical as the number and scope of unmanned vessel or autonomous ship projects increase around the globe. This article provides a brief history of autonomous vessel operations and discusses advanced automation in shipping and the perceived benefits and risks of this emerging technology.

The maritime industry is currently experiencing a sea change in technological disruption through the increased development of advanced automation on unmanned surface vessels ("USVs"). Automated vessel technology is rapidly transiting from the theoretical to the practical as the number and scope of unmanned vessel or autonomous ship projects increase around the globe. Once thought to be decades away from implementation into domestic maritime transportation systems, advanced automation aboard USVs is emerging now as a potentially viable alternative for some industry stakeholders to reduce operational costs, improve safety, and increase productivity and efficiency.

Background

Autonomous vessel operations are by no means a novel concept. In fact, Nikola Tesla anticipated advanced autonomy in the maritime sector in his November 8, 1898 patent for "Method of and apparatus for controlling mechanism of moving vessels or vehicles."[1] Over the past few years though, drawing-board concepts have turned to operational reality in the race to greater vessel autonomy. For many years, Unmanned underwater vehicles ("UUVs") have been used successfully throughout the maritime industry, most

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notably in the oil and gas exploration sector.[2] Commercial surface vessels are now following.

To illustrate, in 2015, Rolls-Royce announced its intention to lead an autonomous ships project and the following year unveiled their vision of the future of remote and autonomous shipping.[3] In 2016, UK-based Automated Ships and Norway's Kongsberg announced their agreement to build the world's first unmanned and fully-automated vessel for offshore operation, the *Hrönn.*[4] The next year, Kongsberg announced their intent to build and operate the world's first zero emission and zero ballast autonomous container vessel, the *Yara Birkeland*, that would be capable of performing fully autonomous operations in 2020 while operating solely in Norwegian waters. The following month, Rolls-Royce and towing operator Svitzer conducted a successful demonstration of a remotely operated commercial tug in Copenhagen, Denmark.[5] And, on September 19, 2017, the Boston-based company Sea Machines Robotics Inc. announced the release of its Sea Machines 300 Autonomous Control System, the first industrial-grade control system that is available standardized off-the-shelf for remote and autonomous control of conventional boats.[6]

As automated technology in the maritime sector continues to advance from mere concepts on the distant horizon to practical applications in the very near future, an urgent debate over how to safely integrate them alongside manned vessels in a cost-effective manner is emerging. The path to autonomy in shipping, however, is not without obstacles. As with other transportation industries and sectors evaluating advanced automation, there are legal, public policy, and regulatory issues which merit debate and careful analysis.

Advanced Automation in Shipping: Threshold Issues

References to autonomous shipping may generate futurist images of a completely unmanned cargo vessel relying on artificial intelligence plying international waters. The reality, however, is that an implementation of automation is not simplistic and will likely be incremental before reaching fully autonomous oceangoing cargo ships, if ever. For example, the discussion of advanced automation in shipping in the near term includes varying levels of autonomy aboard various types of vessels. And although innovators are moving towards fully autonomous oceangoing vessels relying on artificial intelligence, that concept currently remains on the horizon. Therefore, when analyzing vessel operations using advanced autonomy, the threshold analysis is a determination of the level of autonomy to be used, the type of vessel on which the technology will be utilized, and in what location the vessel would be operating. In other words, advanced automation should not be encapsulated within an example of a single autonomous vessel. Rather, automation should be reviewed through several levels of autonomy as part of the overall integration into international trade and the domestic maritime transportation system alike.

Generally, there are various levels of vessel autonomy that may offer clarity to any discussion on proposed maritime operations. While some experts define 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," that definition is only a starting point on the larger scope of potential USV operations.[7] Thus, in an effort to assist ship owners and operators, vessel designers, shipbuilders, and equipment manufacturers to assess opportunity and risk, Lloyd's Register has published guidance in which they define six levels of autonomy beyond manual operations ranging from what they describe as 'AL 1' through to 'AL 6.'[8]

Under manual operations, decision-making is performed without autonomous function with a human in control of vessel actions. 'AL 1' includes on-board decision support in which all actions are taken by a human, but actions are influenced by decision support and on-board systems. Next, 'AL 2' involves on and off-board decision support, in which a human operator takes all actions but systems on or off-board offer decision support tools that may influence selected actions. At 'AL 3,' an active human remains in the loop to perform decisions and actions with human supervision with on or off-board systems providing data. 'AL 4' involves decisions and actions performed autonomously, although a human operator as supervisor on the loop with the opportunity to intercede and over-ride high impact decisions. At 'AL 5,' vessels are fully autonomous with the system making decisions and taking actions under rarely supervised human operations. Finally, 'AL 6' reaches fully autonomous and unsupervised operation wherein the system makes all decisions during the operation or voyage. Vessel operations can also involve a combination of multiple systems at different levels. Overall, these levels of automation are a conversation point that help to refine the discussion on implementation of USVs, and assists in educating industry and the public that USVs may in fact not be a clear cut or an all or nothing operation (i.e., crewed or unmanned).

Once the level of automation is determined, the type of vessel in which to employ the technology becomes more relevant. Generally, there is wide range of vessels which may incorporate advanced automation. In many cases, USVs are well-suited to perform work such as those conducting offshore supply, service vessels for drilling platforms and wind farms, barges, oil spill response, tugboats and towing vessels, or salvage. Additionally, advanced automation may be used in small island passenger ferries through varying levels of automation, such as remote-controlled. USVs are also being considered by governments in support of defense, military and marine scientific research for various missions, including security patrols and minesweeping. This list is non-exhaustive, and even larger cargo and container ships, once thought to be decades away from reality, are now being built to be tested as USVs. Many of these tests ensure that a crew is aboard as a precautionary measure for test voyages, although the end game—likely still decades away—conceivably involves USVs entirely without crew transiting international waters, a concept requiring a legal regime that fully permits USV trading internationally on the high seas.

As USV testing increases on domestic waterways and the high seas, operators must evaluate how their USVs fit within the existing framework of domestic and international regulations in their respective area of operations. However, a regulatory framework specifically for USVs has yet to be developed, and as such, USVs must operate under current rules, regulations, and conventions. There are several guiding regulatory regimes in which manned operations were conceived, such as the International Regulations for Preventing Collisions at Sea (COLREGS), International Convention for the Prevention of Pollution from Ships (MARPOL), International Convention for the Safety of Life at Sea (SOLAS), and International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW). Many coastal states have domestic maritime laws and rules governing these same areas. But, these international maritime agreements and domestic regulations were not drafted with unmanned vessels in mind. Thus, compliance with international and domestic laws remain a hurdle for USV owners and operators to overcome and may require changes to account for autonomous capabilities.

For example, several USV concepts remain in debate, such as who is in charge (i.e., the master) when operating an autonomous or remotely controlled USV, or whether a USV is able to meet requirements for maintaining a "look out" and exhibiting proper navigation lights and shapes.[9] A USV will also need to meet design and manufacturing standards, and discussions on safe manning equivalency requirements and applicability to minimum manning requirements will likely be needed. Moreover, there may be limitation of liability concerns as to the privity and knowledge of the owner in an accident or casualty.[10] Additionally, there remains a gap in standard definitions as to "vessel." Finally, U.S. courts have not considered specific USV operations in any of these areas, and consequently, legal precedent on USV operations is lacking.

However, the International Maritime Organization ("IMO") has taken an initial step in developing a framework for USV[11] when in July 2017 it decided to conduct a scoping exercise to determine how safe, secure and environmentally sound autonomous ships can be fit within IMO instruments.

Domestically in the United States, as with advanced automation in other sectors, regulators are finding themselves somewhat behind the curve of the innovators in promulgating guidance to industry or developing a means to incorporate USVs into the U.S. maritime transportation system. While industry desire for USVs in the United States continues to grow in certain industries, regulators are now beginning to take the first steps to review the issue more closely. In the interim, USV owners and operators should be cognizant of the various legal requirements for testing and operation of USVs, and also should evaluate the current guidance in best practices, such as those established by the U.S. Navigation Safety Advisory Council[12] and the U.K. Marine Industries Alliance Code of Conduct.[13] Overall, industry, innovators, and regulators must work in concert in developing a legally permissive environment for USVs. In other words, if there is not industry interest in the technology, or if regulators do not develop useful and permissive guidance on USV operations, innovation could slow or stall.

Perceived Benefits and Risks

While innovators continue to propel autonomous shipping forward, analysis on the benefits and concerns to practical application of advanced automation in shipping is still developing. Proponents of advanced automation point to a number for reasons for augmenting or replacing humans in the operational loop, including issues related to safety, operating costs, advancing technologies in shipbuilding technologies, and overall environmental compliance.

To illustrate, even with advanced and integrated bridge navigational systems aboard current vessels, human errors can be attributed to as much as 96 percent of marine casualties.[14] Some developers view advanced automation as a means to reduce these marine casualty statistics as decision-making is transferred to highly automated functions to account for quickly changing variables in weather, current, and marine traffic conditions. And, in many cases, USVs are contemplated to support tedious and dangerous maritime activities—since machines do not get fatigued and, if functioning properly, USVs can arguably operate continuously throughout the day without the need to rest.

Also, manning costs for seafarers account for approximately 40 percent of overall vessel operating costs, and the number of mariners required to operate commercial vessels has generally declined over the past century due in part to advances in technology. These day-to-day costs include wages, provisions, travel and repatriation, pensions, insurance, and litigating personal injury claims. Owners and operators in the offshore sector may see these potential cost savings as a means to offset the downturn in the oil market by using unmanned supply boats to service offshore installations. And removing seafarers entirely may limit the risk of piracy and hostage-taking for vessels operating in high-risk pirate waters and may therefore lead to lower insurance coverage rates. Automated technology is thus seen as a potential means to lower the overall cost of running a ship.

Cost savings may extend beyond those associated with vessel operations. Autonomous vessels could be designed to reduce the space aboard vessels allotted for humans and their attendant "hotel" amenities. For example, vessel space needed for crew quarters, air-conditioning, heating, plumbing, piping, bridge, ladderwells, messing, and galley could otherwise be used for profit-increasing cargo.

Autonomous or crewless vessels may also further environmental compliance. Crewless vessels no longer need to manage garbage or treat sewage. Combining autonomy with ships designed to operate with superior fuel efficiency or alternate fuel sources could provide even "greener" ships.

These benefits do not come without risks and attendant counterarguments. As with other automated technologies, some argue that autonomous vessels will adversely disrupt the labor force in the shipping industry. By removing a human from the loop, those in the labor sector could oppose the idea of further automating vessels in an industry on which over a million jobs depend around the globe. Labor unions and seafarers may thus be concerned about what autonomous technology will mean for their jobs. Also, autonomous vessels will spur new training requirements for seafarers to adequately adopt to their integration on waterways.

On the other hand, the introduction of advanced automation could not only improve safety, but also bring new job opportunities and address the expected shortfall in mariner jobs over the next decade. To illustrate, a 2016 BIMCO/ICS Manpower Report forecasted a future shortage of 147,500 officers by 2025 otherwise needed to outfit the world merchant fleet, suggesting a severe gap in the availability of qualified mariners.[15] While autonomous ships may relieve some burden on manning to fill the predicted shortage, it remains likely that humans will never be completely removed from vessel operations, in particular for cases involving remote operations where skilled captains and mariners would be needed to operate vessels from a control station or virtual bridge. Large cruise ships or vessels carrying dangerous cargo could likely keep a small crew contingent onboard as well to address novel issues associated with those vessel operations.

Besides training standards and projected mariner shortages, ship pilots represent another population in the maritime industry for which considerations must be given. For example, if vessels are purpose-built without amenities for humans onboard, such as a navigation bridge, pilots may question the procedures for boarding a vessel upon arrival in a port. Cyber security also remains a primary concern as operators, regulators, and the public need confidence that nefarious actors are limited in their ability to compromise the technology. This is a challenge the maritime industry is facing across-the-board, and USVs will not be any exception.

Conclusions

USVs are poised to be a disruptive technological advancement in the maritime sector. While they offer potential benefits, further discussion is needed to further public acceptance of the technology, and convince industry stakeholders of the reliability of the equipment. Regulators and international governing bodies will play an important role in developing new rules or interpreting current legal regimes to ensure regulatory compliance and that USVs are safely operating in the complex maritime environment. Additionally, labor organizations and pilot associations may oppose autonomous shipping out of concern that the technology will render their roles obsolete. Even so, it appears that various maritime industry factors will continue to drive innovation and integration of USVs. Many hurdles and questions remain, although the maritime community should expect that USVs become incrementally more commonplace much sooner than anticipated.

Notes

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