Autonomous Vessel Technology, Safety, and Ocean Impacts

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Introduction

In this age of automation and robotics, it is not surprising that maritime shipping, one of the oldest and most conservative of industries, is looking to modernize and transform itself by applying autonomous technology to ships much like the automobile industry with self-driving cars and trucks, and the commercial aircraft industry with its aircraft drones. There are two types of autonomous vessel technology currently being explored by various research projects in Europe. One is a vessel operated remotely by a shoreside operator, and the other a vessel operated completely independent of human control; the second has advanced decision support systems onboard undertake all the operational decisions independently.1

The primary driving forces for autonomous ships are twofold: (1) to reduce operating costs as a result of increased operating efficiency, decreased crew and shipbuilding costs that reduce the cost per ton mile of cargo carried, and (2) to reduce potential accidents due to human error, as about 75 to 96 percent of marine casualties are caused, at least in part, by some form of human error.2 The motivation is not to just reduce operating costs and human error but to create a real transformation in the industry. Without humans being physically onboard, the deck house, crew quarters and related ventilation, heating, and sewage systems can be eliminated. Ships can be lighter and more aerodynamic thereby reducing fuel and construction costs and increasing cargo capacity. Those developing autonomous designs anticipate that the remote operations of ships will occur initially, and eventually move towards full autonomy of ships.

1 H.C. Burmeister, “Autonomous Navigation Results From the Munin Testbed,” Autonomous Ship Technology Symposium, Amsterdam, Netherlands, 21–23 June 2016, https://www.cml.fraunhofer.de/content/dam/cml/de/documents/Sonstiges/MUNIN - 160621 - ASS - MUNIN-final.pdf, last accessed 8 September 2017.

2 A.M. Rothblum, “Human Error and Marine Safety,” Bowes-Langley Technology (undated), http://bowles-langley.com/wp-content/files_mf/humanerrorandmarinesafety26.pdf, last accessed 8 September 2017.
Challenges

Although the technological building blocks are all in place for the adoption of a new technology of autonomous ships, the maritime industry is not yet ready to accept such ships. There remain a number of significant and unresolved challenges to be dealt with before such ships can ply the high seas with their cargo. These challenges, although non-technical in nature, offer perhaps greater impediments to autonomous ships than the development of the autonomous technology itself. Of the many challenges, three critical ones rise to the top of a long list: operational, regulatory, and safety considerations.

Operational Challenges

Every ship has to comply with the International Regulations for Preventing Collisions at Sea (COLREGS), which sets out, among other things, the ‘Rules of the Road’ or navigation rules to be followed by ships and other vessels at sea to prevent collisions between two or more vessels. The rules are predicated on having persons on board to make sure these regulations are adhered to. With autonomous ships a critical issue in avoiding possible collision is how manned and unmanned vessels interact with one another, especially when operating in congested traffic areas or in confined waters where the environment can change abruptly due to unexpected events. Verbal communications between manned and unmanned ships are critical and mutual agreement on the course of action to be taken between ships may be necessary to manage traffic.

A remotely operated ship will be limited in the situational awareness needed for making appropriate decisions based only on the information presented on displays. Accuracy of information on displays on a manned ship is validated by actual visual observation. In a remotely operated ship this primary means of validation of the information displayed does not exist. In fully autonomous ships, which are dependent on algorithms for ship detection and classification to obey maritime traffic rules of the road, avoid obstacles, and support decision-making, will the artificial intelligence always make the ‘right’ decisions in possible collision events? Limited situational awareness concerns also apply to the weather and sea state and their impact on the ship.

Displays on screens do not fully characterize or simulate the motions and physical forces of the sea acting on a ship’s hull, which can be critical for safe ship handling in heavy weather and rough seas.

Operations such as docking and undocking are also problematic for autonomous ships. These and other issues related to the operational safety of navigation of an unmanned ship are challenges yet to be resolved.
Regulatory Challenges

Not only are there operational impediments, the current international maritime laws, rules and conventions under which ships and crew operate at sea such as COLREGS, the United Nations Convention on the Law of the Sea (UNCLLOS), the International Convention for the Safety of Life at Sea (SOLAS), the International Convention on Standards of Training, Certification and Watchkeeping (STCW), and the International Safety Management (ISM) Code do not even recognize the existence of autonomous ships.

These regulations presuppose that a master, officers, and crew are operating a ship. With no humans onboard, autonomous ships are effectively prohibited. International law stipulates that the master has command of the ship. Who is the commander of the ship when it is an unmanned ship? The remote operator? The programmer who designed the computer system that runs the autonomous ship? In the event of a shipping accident, where does liability fall?

The STCW for example sets qualification standards for masters, officers, and watch personnel and applies only to ‘seafarers serving on board seagoing ships’. What are the standards of training and competency for a remote control operator and other shore-based personnel if they are considered to be in command of the unmanned ship? The ISM Code, which already imposes obligations relating to the shore-based personnel of shipping companies, would need revision so that the work, responsibility, qualifications and certification of shore-based controllers are properly included in a company’s safety management system. An important and needed change to be made in COLREGS is to insure that all autonomous vessels be identified as a specific ship type so as to be readily identifiable by other ships in night and day conditions, such as by some characteristic lighting and daytime visual display marks or shapes.

In addition to the abovementioned international regulations that need revision, coastal states have national regulations that regulate the operation of manned, but not unmanned, vessels in their waters, which add another layer of regulatory impediments to autonomous ships. Clearly significant steps must be taken to revise and create new regulations that include autonomous ships. Some small steps are being taken to address these regulatory gaps related to autonomous ships. The International Maritime Organization (IMO) as a specialized agency of the United Nations is responsible for promulgating the regulations for ships and their safety, security, and pollution prevention. In 2018, the IMO will begin to address the regulatory gaps by exploring how existing international regulations can be applied to autonomous ships and maritime technologies. Because of the number and extent of regulations involved, it
is anticipated that the IMO effort of revising existing regulations, as well as adding new regulations to address autonomous ships will require at least eight to ten years to complete. With such a long timeframe it is likely that autonomous ships will face the same fate as has occurred with driverless cars and unmanned commercial aircraft drones: the autonomous technology for ships will mature much faster than the development of sufficient safety regulations. Compounding the problem is the fact that not all international conventions and regulations that come into force are adopted by all maritime countries. For example, the United States has not adopted UNCLOS. Even when regulations that come into force are adopted by all countries party to the regulation, there may be delays in enforcement, such as with STCW.

**Safety Challenges**

Safety challenges related to conventional manned ships include ship safety, cargo safety, maritime traffic safety, environmental safety, human safety, and security. These sectors can be particularly challenging for autonomous ships. For example, SOLAS regulations require that a master or person in charge of a ship is to respond to persons who are in distress at sea and is bound to proceed with all speed to their assistance. It is questionable whether an autonomous ship can render assistance as effectively as a manned ship, either in search or rescue situations.

While autonomous ships will keep seafarers safely out of harm's way, there are other safety risks that will increase as a result of having no crew. In the age of unmanned shipping, it would be naive to expect that pirates and terrorists will disappear from the high seas. They may even think that such ships will be new and softer targets. Without a crew, an autonomous ship is likely at greater risk of being hijacked with the purpose of stealing the cargo or kidnapping the vessel for ransom or terrorist purposes. Vessels carrying explosive, inflammable or toxic substances could be used as weapons by terrorists. Because of their dependence on automation systems and artificial intelligence, autonomous ships are much more susceptible to hijackers of another form: hackers. Even as conventional ships become increasingly connected and reliant on software-dependent systems, cybersecurity is already receiving increasing attention by shipping companies. With autonomous ships, cyberattacks will pose an even greater risk to safety and require new and innovative ways to defend against such attacks.

The cybersecurity vulnerability of global shipping was recently highlighted by the cyberattack on container-shipping giant AP Moller-Maersk in June 2017 when a cyberattack downed its online booking and other internal platforms,
forcing it to halt operations at some container terminals. The cyberattack caused a loss of up to US$300 million and disrupted operations for two weeks.\(^3\)

**Conclusion**

Rolls Royce, one of the companies at the forefront of development of remote controlled and autonomous ships, envisions that a remotely controlled vessel operating in local coastal waters (the first stage of autonomous ships) will be in operation by 2020. By 2025 the company hopes to have a remotely operated autonomous ship in international waters, and by 2035 a fully autonomous unmanned ocean-going ship.\(^4\) Once autonomous shipping becomes a reality, there will always be manned vessels as not all ship types lend themselves to autonomous operations (e.g., large passenger ships, ships carrying highly hazardous cargos) so it is essential that autonomous ships be able to co-exist and safely interact with manned ships.

Although the shipping industry’s adoption of autonomous ships may be inevitable, the uncertainty regarding the safety of autonomous ships compared to conventional ships will be tested over time. The common wisdom is that autonomous ships must be at least as safe as conventional ships. One of the greatest risks faced by autonomous vessels will be cyber risks. Cybersecurity will be critical to the safe and successful operation of remote and autonomous vessels. Because of the uncertainty and unknown risks associated with ships having no crew aboard, public sentiment may demand that autonomous ships be even safer than conventional ones.

Even if the technology is perfected, companies are not going to use remote and autonomous ships unless the laws are changed to allow them to operate. Regulations will have to be revised; rules will need to be rewritten. Until that happens, the timeline when these ships will be permitted to operate in ocean trades remains uncertain. Autonomous shipping will happen; it is just a question of when, where, and how.

\(^3\) J. Leovy, “Cyberattack Cost Maersk as Much as $300 Million and Disrupted Operations for 2 Weeks,” *Los Angeles Times*, 17 August 2017, http://www.latimes.com/business/la-fi-maersk-cyberattack-20170817-story.html.

\(^4\) Rolls Royce Advanced Autonomous Waterborne Applications Initiative, “Remote and Autonomous Ships—The Next Step,” White Paper, Autonomous Ship Technology Symposium, Amsterdam, Netherlands, 21–23 June 2016.