SHIP TO SHORE CONNECTIVITY: TRENDS, OPPORTUNITIES, AND ISSUES

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ABSTRACT

Shipping firms constantly look for ways to improve their cost structures. Advanced information and communications technologies are providing the latest opportunities in this effort. Some of the aspirations in the area are centralized command and control, and autonomous vessels. Unfortunately, advances in the architecture of maritime vessels can create serious cost and management problems for maritime ports. This paper looks at current trends in ship to shore connectivity, future opportunities in the usage of information and communications technologies in the management of maritime vessels and ports, and issues that are arising or could arise with the implementation of these advancements.

INTRODUCTION

The maritime industry is continuously looking at new and innovative ways to improve their operations. With the advances in telecommunications, ship to shore connectivity has improved to the point where remote operation of vessels is becoming a reality. The potential associated with these new technologies represent significant opportunities for the maritime industry in costs, cargo handling, safety, etc. These technologies also present threats such as; spoofed automatic identification system (AIS) signals; remote control systems ~~experienced~~ attacks that disabled, disrupted or destroyed Dependent Navigation Systems (DNS); hacked systems; unintended impacts on the environment; and, the industry remains susceptible to human error at the most basic level (e.g., the 2018 collision between a United States (U.S.) naval vessel and commercial freighter in the South China Sea). Furthermore, these advances create new issues for port management, vessel design and operations, crew management, and navigation.

TECHNOLOGICAL TRENDS IN MARINE INTRASTRUCTURE

The maritime industry provides one of the most effective modes of transportation, accounting for 90% of global cargo/trade. As such, it has played a major role in the expansion of business and trade throughout recorded history, having a significant influence on the world economy. For centuries, shipping companies have transported cargo in every form effortlessly. However, with the growing population, imports and exports have increased exponentially in the global markets. This escalation is causing maritime companies to adopt new technologies that provide faster and more efficient trade service. For example, the increase in trade requirements (i.e., more cargo to transport) is causing ship builders to manufacture larger ships with more cargo capacity, while causing shipping companies to introduce advances like blockchain to track and secure the cargo in transit. Much of the new technology trends for ship to shore communications is driven by the need to support the advances fostered by builders and shippers.

Advancements in technology have introduced a number of techniques that have the potential for upgrading the overall operation of the shipping industry. These advancements are gradually improving the industry with better and more advanced machinery and communication tools for making a sailor's life easier. These various technological advancements in the marine industry have affected marine infrastructure, navigation aids, salvage and firefighting support, security systems, and search and rescue facilities.

Robotic Automation

Growth in the use of robots has become quite common in every sector (Zhang, Marani, Smith, & Choi, 2015). In the shipping industry, robots are gradually being used to aid in tasks such as packing, delivering, inspection, firefighting, etc. Given that robots introduce an effective, continuous mode of operation in contrast to human resources, the shipping industry anticipates heavy reliance on robots for every function (Agrawal & Dolan, 2015). Efforts are being made to enable robots to perform manual tasks such as loading and moving cargo. Robotics can potentially be used to perform maintenance and firefighting tasks, while artificial intelligence (AI) can be utilized to locate and navigate ships (Ono, Quadrelli, & Huntsbe, 2014). The combination of these two technologies can detect and eliminate threats of an attack as well.

Due to limited space onboard maritime vessels, the size of robots poses a challenge. New types of robots, called 'mini-robots', are being fitted with sensors to identify and record shipping operations data. In the next few years, advances in robotic automation will considerably reduce manpower aboard.

Autonomous Ships

Waterborne (2015) defines an 'Autonomous Vessel' as a "next generation modular control systems and communication technology that will enable wireless monitoring and control functions both on and off board. These will include advanced decision support systems to provide a capability to operate ships remotely under semi or fully autonomous control". For a vessel to operate under these conditions extensive sensor systems would be needed to detect problematic situations such as unexpected objects in the seas, dangerous weather conditions, and/or potential collision dangers.

The rationale for these types of vessels is that they would require little human supervision or intervention during voyages; thereby increasing the efficiency of ship operations as well as enhancing the sustainability of maritime transport as a whole. From an economic perspective, unmanned vessels would be less costly to operate. In 2011, the average cost of ship operations for bulkers ranged between 31% and 36% of total costs (Gardiner, 2011). From an ecological perspective, there is a tradeoff between bunkering and chartering costs. By slowing transit speeds from 16 knots to 11 knots, bunkering costs could be reduced by approximately 46%, while chartering cost would increase by only 38% (Rodseth & Burmeister, 2012).

Autonomous Systems

Remote and autonomous systems in shipping are gaining acceptance because of their capability to deliver goods without any human interaction. Surface, underwater, and air-based vehicles are being employed for monitoring, inspecting, retrievals, and other types of activities. These autonomous systems utilize the latest, advanced heat mapping and material detection technology in the execution of tasks, thus eliminating human effort. Potential benefits associated with autonomous systems include (Rolls-Royce, n.d.) reductions in potential for human error; more efficient use of space in ship design; and more efficient use of skilled crews. Furthermore, unmanned cargo vessels would not need superstructure supporting human activities, thus creating more cargo space.

TRENDS IN INFORMATION AND COTMMUNICATION TECHNOLOGIES (ICT)

Today's maritime communication solutions have evolved from analog devices to digital (Chatzigiannis, Gibson, & Singh, 2013). Line of sight communications have been enhanced with satellites. Voice communication is being replaced with computers and the Internet. Logistics are becoming more complex increasing the need to digitalize information streams. Some of the potential benefits are optimization of existing infrastructure; reduced need for additional capital investment; possible reduction or elimination of unnecessary (empty) transport; increased collaboration; and increased comparative advantage for both ports and shippers from big data analytics.

The trend of forcing cell phone companies to sell access by the gigabyte has begun to transfer to maritime services. Due to the threat of crew broadband data usage overwhelming a vessel's data network, provider services for data access at sea need to address increasing operational demand. The solution of simply adding bandwidth capacity and data speed is not enough, because history shows that eventually there will be new ways of consuming capacity.

Ship operators are beginning to demand greater transparency in how data is being used and how much is needed. This transparency will provide owners and operators with a better understanding of usage trends.

Research shows that maritime user applications requiring access to communications systems can be divided into six main areas: safety and security; vessel operations; regulations and policy; tracking and monitoring; crew welfare; and, shared situational awareness (Plass, Clazzer, Bekkadal, Ibnyahya, & Manzo, 2014).

The Growth of Sensor Technology

Advancements in sensor technology have broadened technological capabilities. Since the introduction of sensors, the need for manually checking equipment onboard ships has been greatly reduced. The ability to connect equipment to sensors through wireless connectivity has enabled crews to keep accurate tabs on a machine's working condition, the intervals between required maintenance activates, and the overall monitoring of vessel operations. In addition, when sensors are combined with machine learning and artificial intelligence, shipboard data can be analyzed remotely, and alerts can be sent out immediately when there are aberrant behaviors in operations or when maintenance is required.

Internet of Things (IoT)

IoT is an ecosystem of open-source data that ships can leverage for various use such as acquiring weather data for navigation, or tapping into a public camera to view the port area. Using a global positioning system (GPS), a cloud-based database, and a wireless network, data collected by various sensors, robots and other devices onboard the ship can be accessed, analyzed, and acted upon if necessary. As this technology matures, shippers will eventually be able to remotely control onboard systems critical to autonomous vessels, shipboard optimization, and other functionality. Currently the advantage of IoT is in keeping track of all devices and shipments. This allows the shipping industry to provide better customer service with information about the location, time of arrival or delay in shipment.

Navigation Aids

Navigation aids have been utilized for centuries to help ships sail safely across oceans, avoiding hazards and other dangers. The evolution of navigation aids is increasingly reliant on information technology for the elimination of human errors in transmission and improving efficiency. Technology has played an important role from the very beginning from the development of nautical charts, lighthouses, beacons, and buoys, to GPS, electronic charts display and information systems (ECDIS), satellite based aids, automatic identification systems (AIS), etc.

These advancements are making navigation easier and more effective. In addition to making navigation safer, these virtual systems are easily installed and have lower maintenance costs than physical navigation aids. Unfortunately, tying everything to one electronic backbone has made unauthorized remote access and attack much easier.

The International Maritime Organization (IMO) defines e-navigation as "the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment" (Plass et al, 2014, p. 5). The continued evolution of e-Navigation will require higher digital data exchange and bandwidth capabilities than is currently available. The specific user needs and potential e-navigation solutions proposed by the IMO are shown in Figure 1 below, which for the sake of simplicity does not show the operational and technical interactions between different shipboard environments. The IMO project has identified some possible future developments in the field (Plass et al, 2014):

- Improved harmonized and user-friendly bridge design that integrates bridge equipment and navigational information, and presents the information in graphical displays;
- Improved reliability and flexibility of on-broad position, navigation and timing (PNT) systems;
- Improved shore-based services through means of standardized, automated ship-to-shore reporting.
- Improved access to search and rescue (SAR) information;
- Improved communication of vessel traffic system (VTS) information.

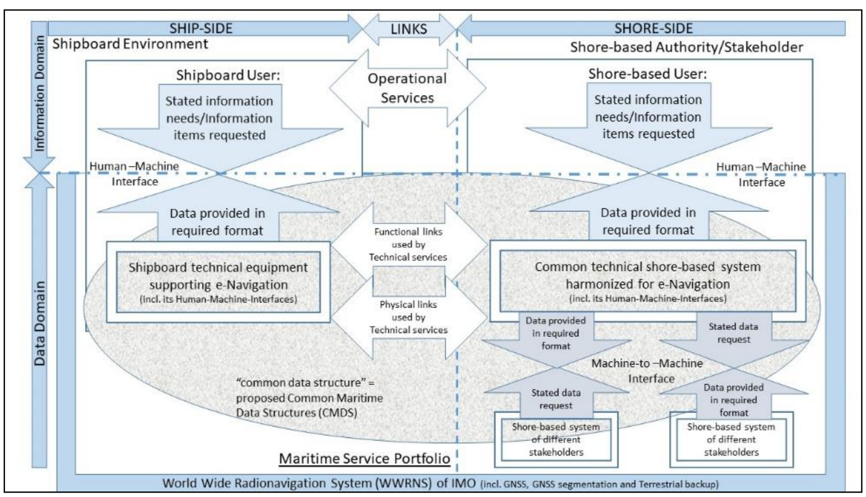

FIGURE 1. POTENTIAL E-NAVIGATION SOLUTIONS

Search and Rescue

Even with all of today's modern advancements, sailing the seas is hazardous; ships can be lost, hijacked, or wrecked. In such cases, ICT has proven to be invaluable for running search and rescue operations. The global maritime distress and safety system (GMDSS) provides maritime authorities status on vessels in distress. Ship-to-shore security alerts, satellite-based location detection, and digital calling are just some of the means for sounding distress alerts. Transponders and handheld personnel location detectors can be used to detect the position of ships and sailors in distress with extreme accuracy.

Given the real-time nature of such capabilities along with the establishment of virtual boundaries for early notification, SAR activities are transitioning from reactive to proactive. Prevention and mitigation strategies along with training are reducing the number and impact of events. With improved connectivity, simulators can enhance training activities and improve crew reaction times and decision-making capabilities.

Crew Welfare and Safety

The modern seafarer is demanding better communication connections to home; thus, ships are providing access to social media, news, movies, television entertainment, and music while at sea. They also want better training and professional development, as well as better working conditions.

Lukas (2010) notes that, "ranging from marketing and design over manufacturing support to familiarization, training and maintenance assistance, there is no phase in the lifecycle of a ship or seaborne structure that would not profit from 3D modelling, simulation, virtual/augmented reality or computer vision." Other areas that could benefit from improved ship to shore connectivity are:

- Crew management may be eased through the provision of an online scheduling system, permitting crews to know and manage their crewing schedules in advance;
- Professional development may be achieved through Computer-Based Training (CBT) that offers onboard testing for certification and career advancement;
- Gaming can be integrated with more advanced land-based simulators, advancing knowledge while reducing a crewmember's landside time commitment. This benefit may be offset by reducing a crew member's time with his or her family;
- Human resource management and quality of life needs may be automated, providing crewmembers the ability to address issues such as health insurance and remittance regardless of whether they are at sea or not.

Game engines can combine handling and rendering of 3D objects in an efficient way to simulate interaction and behavior. This mixture of gaming and simulation allows for interactive training (Wolfe & Crookall, 1998). One example of the usage of the game approach is the PC-based shipboard virtual fire-fighting application that is part of a blended learning course for basic fire-fighting (Deistung, Lukas, Sedlacek, & Kucha, 2008). Simulator based training has been used for decades to train aircraft pilots and nautical officers. One of the challenges in the development of simulations is the replacement of complex equations of motion with accurate approximations that are solvable in real-time. This human-in-the-loop approach allows for the optimization of the simulated vessel (Smith & Cheok, 1998). Another challenge is the usage of real-time graphics in the simulation. This practice offers an extremely efficient approach for practicing the handling of complex technical objects (Ridan, Batile, Ribas, & Carreras, 2004).

Security Systems

The maritime industry continues to face threats that have a harmful impact on crew, ship, and country. Some of the threats are piracy, hijacking, armed robbery, smuggling, narcotics, illegal migration, etc. In an effort to mitigate or eliminate these threats, new methods of enhanced security have been implemented. Advanced technologies contribute significantly in achieving this goal in several ways (SHM Shipcare, 2018):

- X-ray, gamma ray, and neutron scanners are used to detect explosives and drugs;
- Biometrics such as facial recognition, figureprint identification, iris/retina scanning, voice recognition, etc., provide safeguards in sensitive operational areas;
- RFID (Radio-frequency identification) tags, smart robotic underwater surveillance, and sensor-based controls are used to maintain security.

Security can generally be divided into two groups – physical protection systems and cyber security (sometimes referred to as information security). Within both of these groups there are four basic elements – detect, delay, response and mitigate. For the shipping industry, this includes both landside and onboard systems.

Bullets 1 and 2 are examples of detection that can be both landside and onboard. Delay mechanisms include electronic security fencing, slippery foam (denial system) and stun grenades—all non-lethal onboard systems. Response mechanisms include automated anti-boarding devices such as water cannons and razor wire canisters. Bullet 3 is a mish-mash of things with RFID and robots being detection, and sensor-based control (usually referred to as Process Control Networks) being detection, delay & response.

OPPORTUNITIES

It is increasingly vital for maritime ships at sea to be able to communicate and exchange information with a shore network. Transferring files, database access, e-mail, web/intranet browsing or video conferencing, and other such services are all important facets of such information exchange. Currently, these activities are accomplished with satellite communications, which is expensive and slow. As vessels near the shore, alternate methods of communicating are typically faster and cost less than satellite-based services (Rolls-Royce, n.d.). Thus, as vessel designs and technology evolve, the land-based components supporting them must also evolve. In addition, advances in telecommunications, automation, and vessel design will present opportunities for innovation in how ships are maintained, supplied, and crewed.

Automation

The advancement of technology is providing port authorities with new and better methods of controlling port and terminal activities. By integrating technology into these activities, intelligent solutions for efficient control of traffic and trade flows through ports promises to increase port capacity and efficiency. This trend towards automation in process flows and operations conducted at ports is driving significant change in the way maritime trade is conducted.

Currently, many ports have integrated technology to some extent into their operations. Initiatives from government coupled with an exponential growth of maritime trade has gradually increased the number of smart, automated ports or mega-ports. These smart ports generally deploy cloud-based software to assist in creating operational flows that help the port to function smoothly. The degree to which ports have automated their operations differs, contingent on the capacity, location, cargo volume, and cargo economic value. The implementation of automation is occurring across port processes including; material unloading and cargo handling equipment, digitization of ship records, inventory management, infrastructure, vessel docking and maintenance, and more.

Big Data and Data Management

Port information use is evolving beyond docking ships. Stakeholders within the port ecosystem are coming together to devise new data-driven processes and practices. As the maritime industry becomes more complex, a variety of agents, ranging from cargo and logistics companies, storage providers, rail and barge operators, trucking companies and original equipment manufacturers (i.e., sensor providers for pipelines, cranes, berths and roads) are exchanging information in real time.

Intelligent solutions and services are helping ports increase productivity and efficiency, as well as improve collaboration and information sharing between the port authority and its various stakeholders. These technologies generate large amounts of data in many forms and must be shared with many different port stakeholders. Examples include:

- The usage of real-time data in ship inspections: By coupling advanced sensor technology with small, autonomous vehicles inspection, speed can be increased saving time and money;
- Improved weather condition and water levels predictions: With accurate information on weather and water conditions, shipping companies can determine the best time to bring their ships into port, potentially saving money and time;

- Improved tracking and monitoring of resources: Real time information on the availability and operational efficiency of cargo handling machines such as cranes and trucks is essential to making good decisions on cargo handling and transfer;
- Regulatory compliance: Remote advanced communication of the condition of a ship, its crew and cargo, and port facilitates time-consuming processes such as Customs clearance, Coast Guard safety inspection, and security protocols mandated by the International Ship and Port Facility Security (ISPS) Code.

3D Printing Opportunities

The evolution of 3D printing is driving manufacturers towards the goal of zero-inventory. Many ships are now incorporating 3D printing capabilities onboard. This impacts the ship directly allowing for the immediate printing of parts when breakage is encountered. It may eventually transform the way ships are supplied in the future – cargo streams will most likely transition to more shipment of raw materials rather than end products.

3D printing will likely reduce the need for original parts from OEMs. The degree to which it will reduce the quantity of items shipped is unknown. One factor that will affect the answer to this question is that, after an item is printed it still needs to get to where it will be applied, which means the volume of shipping is directly tied to the number of locations where 3D capabilities are located. As trade patterns alter, new opportunities will emerge to service new manufacturing requirements to ship materials out for recycling and refurbishment.

ISSUES

Though technology is becoming more prevalent in shipping, it has not replaced manual involvement. It is important that technology be seen as a valuable tool to assist shipping operations and used accordingly. Technology, applied properly and updated frequently, can ensure a competent and competitive shipping industry in the near future. Even so, there are challenges yet to be mastered; these include the following.

Data Management

Data management includes data collection, data storage, and data processing. In today’s data-rich world, making better decisions is not possible without good data management. For example, without rigorous data, it is least extremely difficult to perform reliable cost-benefit analysis, accurate forecasts, or make effective operational decisions within the maritime environment (Deistung et al, 2008). Advances in data collection and management offer the broadest, easiest, and most cost-effective method for advancing vessel operations and port management (Kenyon, Neureuther, Zhou, & Goldsmith, 2018). Data management requires minimal capital expenditure, but offers significant returns to all parties. The absence of rigorous data makes it difficult to perform reliable cost-benefit analysis, develop accurate forecasts, or make effective operational decisions within the maritime environment (CMAIS, 1999). There are numerous articles that discuss supply chain practices related to enabling IT systems including vendor managed inventories, virtual integration, just-in-time purchasing, collaborative planning, forecasting, replenishment, and governance programs (van Hoek, 1999; Waller, Johnson, & Davis, 1999; Raghunathan, 1999; Wang & Wei, 2007; Caroline, 2018). Some of these solutions can certainly be applied to ship operations and port management. However, in order to adopt the best practices, it is crucial to identify the right data points and collection methods. Key data collection areas include, but are not limited to, asset movement (ships, trucks, cargo), asset environment (cargo content, cargo processing, customs clearance), and end user management (global supply chain).

One of the challenges going forward is not how to capture data but rather how to manage and leverage the information that has already been generated to create value (Caroline, 2018). With a data sharing solution, ports and ships could collect, combine, and analyze many sources of relevant information before a ship arrives at a port. Another challenge is the centralization and management of the information produced by the many stakeholders in the maritime industry (Wingrove, 2018).

These types of initiatives will increasingly rely on data sharing platforms and application programming interface (API) centric solutions for the linking of data from different sources, including shipping and logistics companies; weather, ship inspection, bridges and railway sensors; and the ports themselves.

Data Collection

Data collection seems straightforward, but will encounter problems without a thoughtfully developed comprehensive collection plan. Two critical port management mistakes in data collection happened over the past decade in dozens of ports throughout the Americas, Africa, Asia, and the Middle East. The first mistake was collecting information only for a specific purpose because decision makers tend to think in terms of information rather than data (Kenyon et al, 2018). The data collection process should be focused on the gathering and measuring of information on targeted variables in a systematic fashion that enables one to answer relevant questions and evaluate outcomes. As such, data is an asset that supports decision-making. Allowing the questions and outcomes to dictate what data to first collect creates vulnerabilities in the knowledge comprehension of the individual(s) formatting the data limiting flexibility in addressing environmental changes.

For example, the Philippine Ports Authority (PPA) collects vessel traffic information for the express purpose of national port management and business development. To that end the PPA decided that the data required to meet their needs included the ship owner, the port of origin, the port of destination, the transit departure time, the arrival and duration times, the cargo description, and the cargo value. If other data was collected beyond the PPA's specific intent (such as a vessel description, crew identification information, and vessel routing), the data collected would be available for other purposes such as port security. In fact, this new data could then be used to improve navigational safety and country marketability when the need arose (Kenyon et al, 2018).

The second mistake in data collection was that stakeholders collected information only within their own vertical functions (Kenyon et al, 2018). This produced stove-piped information cells, duplicated data collection efforts, and conflicting information. To overcome this issue, data must be collected and coordinated at the port management level, not at the individual stakeholder level. Unfortunately, this form of data collection is typically abandoned the moment the issues of proprietary information and business competitiveness are broached.

Representative of this issue (Kenyon et al, 2018), the Philippines Bureau of Fisheries and Aquatic Resources (BFAR) established a vessel monitoring system to track commercial fishing vessels. Administrative and operational practices and equipment were instituted to collect information specific to BFAR's requirements. While access to this output was granted to other port stakeholders, neither the data nor the equipment was applicable or compatible for other functions such as the tracking and monitoring of non-commercial fishing vessels.

In the private sector context, Philippine terminal operators such as International Container Terminal Services, Inc. (ICTSI) and Asian Terminals Incorporated (ATI) produce require raw data germane to the Port Community System (PCS). For example, ICTSI and ATI equally benefit from knowing the status and nomenclature of a ship that may visit both terminals. Present day industry practice requires each terminal operator to independently collect raw data. This results in cost duplication within the PCS.

Data Security and Information Privacy

Hackers remotely taking control of systems is the new "hole in the fence" of port and vessel security. Though the use of various control systems and automation in operations will reduce the risk of human errors and increase the reliability of the system; technology also has a dark side.

As usage of the internet expands into shipping apparatus and operations, cyber security becomes of utmost importance. Management of this issue will force changes in operational policies, making regular testing and data audits a standard routine aboard the ships. As the scale of data to be captured and stored in secure servers for reference and analysis increases, vessel designers and port authorities will need to determine network infrastructure and equipment needs, the associated power and cooling requirements for that equipment, as well as space requirements.

Software and device developers need to ensure that appropriate security standards are maintained whenever new technology applications are developed. Ship operators and port authorities will need trained personnel to maintain and operate the equipment and networks. As cybersecurity and cyber-resilience become more important, port authorities will need to be prepared to deal with existing and emerging cyber threats from criminals, terrorists and enemy nation states intent on shutting down large pieces of the country's maritime transportation system. This preparation is not just technological; it is also cultural. Port and Vessel managements need to develop a risk-aware culture within their various organizations.

Scaling of Transportation

The determination of the value of maritime transport is shifting away from scale toward the degree to which relevant technological advances are being leveraged (UNCTAD, 2018). As the nature of the shipping industry evolves, its infrastructure needs to change with it at a comparable rate. The size of ships, trains and trucks are expected to increase over the next 15 years. As vessels increase size and capacity, ports will need to increase channel depths, widen docks, and increase the strength and capacity of quays and cranes. As transshipment becomes more structural to the industry, the need for cooperation between ports will increase in order to secure optimal transport. These types of major infrastructural projects typically take up to 15 years to complete.

Autonomous Shipping

The development of autonomous shipping holds great opportunities for the shipbuilding and shipping industries. But it will also require the development of new competencies before autonomous ships can become a commercially viable reality. Research must improve sensor technology, as well as the acquisition of high-resolution ranging data and instrumentation accuracy. Software development will play a very significant role in enabling situational awareness, a prerequisite for automated decision management.

Another concern is the operational availability of on-board machinery. Because immediate repairs will not be possible on an unmanned craft, the reliability of all mechanical and electronic components need to improve.

Furthermore, there exists no legal framework that governs the use of unmanned ships. Rules and regulations will need to be developed to avoid potential conflicts with international law before autonomous ships can operate in international waters. Because these vessels can travel great distances, well-trained crews who can respond quickly to any technical issue will need to be available at a moment's notice. If an unmanned vessel has a technical issue in the open seas, it can take days before it can be reached and the problem fixed. This would not be safe or economical.

FINANCING RISKS AND MECHANISMS

Autonomous shipping is not without its risks. These include, "Cyberattacks, piracy, casualty management, vessel maintenance, assignment of liability and safety…" The primary way to deal with such risks is through marine insurance. However, the industry is struggling to deal with the paradigm shift of autonomous shipping (Smith K. , 2017). This shift has been described as "the biggest revolution in shipping since sail gave way to steam" (HFW, 2019). Autonomous shipping could also mean "the end of thousands of years of maritime law and risk management" (Morris, 2018).

Marine insurance, complex from the beginning, was also very profitable because, unlike life insurance, it is fairly easy to sell. According to Zelizer (1979), "Marine insurance was the first type to be established, and it developed with ‘inconceivable rapidity,’ becoming so profitable ‘that it may truly be said to have laid the foundation of many fortunes in our country.’ As early as 1721, it was said to be ‘very much for the Ease and Benefit of the Merchants and Traders.’ In that year, John Copson opened in Philadelphia the first marine insurance office. The demand grew, and by 1750, offices operated in Boston, Philadelphia, New York, and other commercial centers. Marine policies were also being sold extensively by private underwriters. The Insurance Company of North America became the first incorporated marine office in 1794. By 1798, it was collecting nearly $1,500,000 in premiums from Philadelphia alone.”

The complexity of marine insurance has long been recognized. Unlike life insurance or fire insurance, which both deal with single event types, marine insurance must indemnify “…against the loss of ship, goods, freight, anticipated profits, or any other insurable interest, through any of the numerous perils and adventures connected with navigation, such as the "perils of the sea," fires, collisions, pirates, thieves, seizures and restraints, jettisons, barratry of the master or mariners, and all other perils, losses or misfortunes which might be assumed by the policy” (Huebner, 1905). Since complexity has always been at the heart of marine insurance, the industry should be able to deal appropriately with these new concerns.

One of autonomous shipping’s interesting wrinkles is that it shifts the risk from the crew on the ship to software developers. Jarle Fosen, loss prevention expert for marine insurer Gard, notes, “The root cause of most [crew related accidents] are issues such as fatigue, inadequate communication, lack of knowledge of the ship’s system and decisions based on incomplete information.” These risks, according to Fosen, have the potential to be reduced with autonomous shipping (Smith K. , 2017). However, Andrew Kinsey, a senior marine consultant with Allianz Global and Corporate Specialty, argues that “Removing the humans from the vessels does not eliminate the human error. It just moves the human error from the helm to the coder” (Morris, 2018). The recent problems with Boeing’s 737 Max navigational software have brought to light many of the risks involved with relying heavily on software solutions to navigational issues with “The future of the 737,” according to *The Wall Street Journal, “*rest[ing] on the [software] fix” (McCartney, 2019).

The liablilty of collisions at sea has until recently been the responsibility of shipowners. That changes when there is no crew on board because the liablity shifts from the navigator to the software aker (Smith K. , 2017).

Cyberattacks on autonomous ships will inevitably happen. In fact, cyberattacks have been launched against GPS systems on manned vessels. Somali pirates use cyberattacks to hack in to onboard navigation systems so that they can “identify vessels in the Gulf of Aden carrying valuable cargo.” Marine insurance policies often exclude cyberrisk, which means shipowners should also carry separate cyberrisk insurance policies (Grasso & Hall, 2015). However, cyber insurance has not caught on quickly. Andrea Schlayer, a cyber underwriter for Munich Re, argues that marine underwriters can learn to understand cyberrisks more readily than cyber underwriters can learn the marine underwriting industry. The risk from cyberattacks are difficult to quantify because they often go unreported. However, losses have been relatively small, but as shipping increasingly relies on software for navigation, such losses are bound to increase, and the current gap in cyber insurance will need to be addressed (Morris, 2016).

From a legal standpoint, the very definition of what constitutes a vessel in unclear with autonomous shipping. In fact, Stephen J. Harris of Marsh & McLennan Companies posits that “The legal complications of crewless vehicles are actually more complicated than the technology.” There is no precedence for dealing with a crewless vessel if it sails into the port of a nation that has no regulation dealing with the issues of autonomous shipping. Harris also wonders who would be responsible, “If an operator did everything fine but a system went down.” Even if the system’s designer accepts responsibility, “what matters,” according to Harris, “would be the flag state’s law in international waters and the local state’s law in territorial waters.”

As in many instances regulation significantly lags technology and must quickly catch up globally for mass autonomous shipping to reach its full potential (Morris, 2018).

CONCLUSION

The maritime industry is facing many challenges ranging from economic contractions, overcapacity, rising freight rates, high fuel prices, piracy, environmental impacts, to labor shortages [24]. Innovation and technology can solve many of these issues. Governmental policies and behavioral changes can help with some of these issues. Regardless of the solution methodology, maritime transport is vital to everyone, and as such, solutions must be found.

As vessel designs evolve along with advances in automation technologies, the costs and productivity associated with maritime transportation will be greatly improved. In addition to these improvements, parallel improvements in ship to shore connectivity must also be achieved. Not only does improved communications and decision making improve both ship and port operations and safety, it is demanded by the marketplace.

The maritime industry plays a critical role in the world economy. With the advances in ICT, ship to shore connectivity has improved dramatically and has potential for further improvement. In the meantime, many challenges for ship to shore connectivity exist that must be resolved.

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