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A Review on Simulation Based Training on Autonomous Ships and Protection of Egyptian Maritime Security

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ABSTRACT

Purpose: *Autonomous ships are gaining more and more favor in the maritime sector as a result of their ability to boost productivity while simultaneously lowering costs and boosting levels of safety. However, the proliferation of autonomous ships brings with it new worries about cybercrime, piracy, and other challenges to maritime safety and security. Protecting marine security is of the highest significance in Egypt since the Suez Canal is an essential transportation route for international business.*

Design/Approach/Methodology: *This research study investigates the function that training plays in improving both the general security of autonomous ships that operate in Egyptian seas as well as the cyber security of such ships.*

Findings: *This research summarizes the findings of the available literature on training for autonomous ships and maritime security. The paper also evaluates this literature. According to the findings of the research, even though there is a rising knowledge of the significance of training for autonomous ships, there are substantial gaps in training programs and resources in Egypt. This is even though there is a growing awareness of the value of training for autonomous ships. The findings of the research are summarized in a set of suggestions for boosting Egypt's marine security and the quality of its training programs.*

Key-words:
Autonomous Ships, Maritime Security, Cyber security, Simulation Based Training.

INTRODUCTION

It is anticipated that the deployment of autonomous ships in the maritime sector would provide considerable advantages in terms of increased efficiency, decreased costs, and increased levels of safety. However, the deployment of autonomous ships gives rise to new worries about cybercrime, piracy, and other dangers to maritime safety and security. Protecting marine security is of the highest significance in Egypt since the Suez Canal is an essential transportation route for international business. This research study investigates the function that training plays in improving both the general security of autonomous ships that operate in Egyptian seas as well as the cyber security of such ships.

With the Suez Canal acting as an essential connection between Asia and Europe, Egypt is an essential participant in the international marine sector. Over twelve percent of annual worldwide commerce is estimated to go through the Panama Canal, making it one of the busiest shipping channels in the world (Khalifa and Salem, 2019). Because of the canal's significance to international commerce, there is a greater chance that it will be the target of security risks including piracy, terrorism, and smuggling. The use of autonomous ships brings up additional problems about cyber security, in addition to the previously mentioned conventional security risks.

Autonomous ships are a relatively new technology that is undergoing fast development and have the potential to revolutionize the shipping sector. These vessels navigate and carry out their operations at sea without the assistance of humans by using cutting-edge technology such as artificial intelligence. The deployment of autonomous ships has the potential to boost productivity while simultaneously lowering costs and raising levels of safety. On the other hand, the widespread use of autonomous ships brings up new worries about cyber security. The risks associated with cyber security include the possibility of being hacked, infected with malware, and experiencing various types of cyber-attacks. These dangers have the potential to endanger the ship's safety as well as the security of its crew and its cargo. The crew has to have proper cyber security training in order to reduce these risks and guarantee that they can react correctly in the case of a Cyber-attack (Ghaderi, 2019).

The adoption of autonomous ships raises concerns regarding the emergency safety and security of the vessel, its crew, and its cargo, in addition to cyber security threats. Effective training in emergency response is vital to guarantee that the crew can react effectively to crises and reduce the risk of harm or loss of life. This training is essential because it helps ensure that the crew can respond appropriately to emergencies.

Given the essential significance of maritime security to the Egyptian economy and the possible hazards connected with the adoption of autonomous ships, there is an urgent need for effective training programs to strengthen the cyber security and overall security of these boats (Ben Farah et al., 2022). This requirement has been exacerbated by the fact that the adoption of autonomous ships is expected to increase in the near future. These training programs need to be thorough, up-to-date, and relevant to the shifting dangers that face marine security. In addition, the many stakeholders in the marine sector need to collaborate in order to guarantee that effective coordination is maintained throughout the process of developing and implementing these programs. Egypt can contribute to the sustained expansion and economic success of the global maritime sector if it improves the training programs and resources that are now available. In doing so, Egypt can assist to guarantee the safe and secure operation of autonomous ships inside its territorial waters (Ash and Scarborough, 2019; Ampah et al., 2021).

Therefore, the purpose of this research is to conduct a literature review on training for autonomous ships and maritime security, as well as provide the findings of a survey that asked Egyptian maritime stakeholders about their views on the significance and usefulness of training for autonomous ships. The purpose of the research is to determine where Egypt's training programs and resources are lacking, and then to give suggestions for how those programs and Egypt's maritime security should be improved.

LITERATURE REVIEW

The introduction of driverless ships is a technology that is undergoing fast development and has the potential to bring about a sea change in the shipping sector. The deployment of autonomous ships has the potential to boost productivity while simultaneously lowering costs and raising levels of safety. However, the proliferation of autonomous ships brings with it new worries about cybercrime, piracy, and other challenges to maritime safety and security as listed in MSC 106/INF.20. MSC 106/INF.20 lists some of the safety risks that could come with using driverless ships, such as cyber security risks, communication problems, and the chance of a ship colliding with another. Also, MSC 106/INF.20 talks about how Maritime Autonomous Surface Ships (MASS) might affect the marine workforce, such as by changing job roles and making it necessary to learn new skills and get new training. The paper stresses how important it is to give sailors and other people who work on driverless ships the right training and licensing to make sure the

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ships run safely and efficiently.

Protecting marine security is of the utmost importance in Egypt because of the importance of the Suez Canal to international commerce. This literature review takes a look at the research that has already been done on how to train autonomous ships and improve maritime safety. The purpose of the evaluation is to give suggestions for strengthening training programs and increasing marine security in Egypt, as well as to identify any gaps that exist in Egypt's training programs and resources. The research that has already been done on how best to train autonomous ships and ensure safety at sea is analyzed in this literature study. The study indicates that while there is a rising understanding of the necessity of training for autonomous ships, there are still substantial gaps in training programs and resources. This is even though there is a growing knowledge of the importance of training.

The significance of cyber security in relation to autonomous ships has been the subject of several studies in recent years. The risks associated with cyber security include the possibility of being hacked, infected with malware, and experiencing various types of cyber-attacks. These dangers have the potential to endanger the ship's safety as well as the security of its crew and its cargo. The crew must have proper cyber security training in order to reduce these risks and guarantee that they can react correctly in the case of a cyber-attack.

In the context of autonomous ships, Crespo et al. (2019) places a strong emphasis on the significance of cyber security. The research sheds light on the dangers that might arise from cyber-attacks on autonomous ships as well as the need to receive adequate training in cyber security. Accordingly, cyber security training for autonomous ships need to center on techniques for detecting and counteracting cyber-attacks, as well as on the most effective methods for protecting the ship's information systems and data.

A study on the present state of the art in autonomous shipping and marine cyber security was carried out by Kovanen (2021). This research underscores the necessity for good cyber security training for autonomous ships. This training should include instruction on the most recent technological advancements and best practices for cyber security. Moreover, it is recommended that experienced cyber security specialists provide training on cyber security for autonomous ships. Additionally, the training should be adapted to meet the unique requirements of the ship and its crew.

Other research has focused on the significance of education and training for marine safety on a global scale (Chapsos, 2016). Smuggling, piracy, and terrorist attacks are all examples of dangers to maritime security. These dangers have the potential to have substantial repercussions on both the economy and society, in nations such as Egypt, where marine commerce is an essential component of the economy. Effective training for marine security may assist in minimizing these risks and ensure that crew members can react effectively in the event of an incident. Training can also help to ensure that crew members are able to respond appropriately.

Upadhyaya (2018) carried out a comprehensive analysis of the dangers, difficulties, and potential answers regarding maritime security. According to the findings of the research, adequate training for marine security is very important. This training should include topics such as emergency response, piracy, and terrorism. Furthermore, training programs have to be comprehensive, current, and adapted to the particular requirements of the vessel and the people serving on it.

A study of the regulatory and legal problems related to autonomous shipping and marine security was carried out by Zhang and Roe (2019). According to the findings of the research, robust training programs for autonomous ships are desperately needed. These programs should include instruction on topics such as cyber security, emergency response, and piracy. Additionally, various stakeholders in the maritime sector, such as training providers, regulators, and ship owners, should work together to establish training programs.

Guidelines for the categorization of autonomous ships have been prepared by the International Association for Classification Society (IACS, 2020). These recommendations emphasize the need of competent training for autonomous ships, particularly training that covers topics such as cyber security, autonomous systems, and emergency response procedures. According to the standards, training programs should be established in conjunction with various stakeholders in the maritime sector, and they should be adapted to meet the requirements of the ship and the individuals serving on it.

The IMO has produced standards and recommendations on the education and certification of seafarers, including those who operate aboard autonomous ships. In its standards, the IMO emphasizes how important it is for autonomous ships to have adequate training, which should include training on topics such as cyber security, emergency response, and piracy (IMO, 2021a). The guidelines also indicate that training programs should be designed in consultation with stakeholders in the maritime sector and should be adapted to the individual requirements of the ship and its crew (IMO, 2021b). This is one of the recommendations that are included in the guidelines.

Marine Insight (2021) is an online resource that is geared at the marine business and gives information on the most recent trends and advancements that have occurred in the sector. There are articles on the website that discuss autonomous ships as well as the future of the maritime industry. The website emphasizes the significance of proper training for autonomous ships, including training in cyber security and emergency response, as well as training on the most recent technological developments and industry standards.

An investigation of marine transportation was carried out by the United Nations Conference on Trade and Development (UNCTAD) in the year 2019. The significance of the marine sector to the economy of the whole world is brought to light by the findings of this research, as is the need for efficient training programs to guarantee the safe and sound operation of ships. According to the findings of the research, training programs have to be comprehensive, current, and adapted to the particular requirements of the vessel and the people serving on it.

Existing research emphasizes the significance of good training for autonomous ships and maritime security; yet there are still substantial gaps in training programs and resources despite the fact that these issues have been brought to light. These deficiencies include the absence of training programs that are both comprehensive and current, the absence of collaboration amongst stakeholders in the formulation and execution of training programs, and the absence of funding for training programs. In addition, there is a need for the development of training programs that are adapted to meet the particular requirements of the ship and the crew, and that also take into consideration the growing dangers to maritime security.

METHODOLOGY

Search Strategy

The researcher employed a systematic strategy to perform a complete literature evaluation, which included scanning a range of electronic databases, including Google Scholar, Scopus, Web of Science, Science Direct, and other relevant sources. He ensured that his search was comprehensive and inclusive by utilizing a variety of databases, gathering a wide range of papers regarding "Egyptian Marine Protection and Training on Autonomous Ships.» The researcher utilized a mix of keywords and related phrases, such as "autonomous ships," "maritime security," "cyber security," "training," "Egypt," "Maritime Safety Committee (MSC)," and others, to narrow his search. He attempted to gather the most relevant and up-to-date information on the issue by using these precise phrases, to ensure that his evaluation was complete.

Inclusion and Exclusion Criteria

The studies were screened based on their relevance to the research question. The inclusion criteria for the studies were that they should focus on training for autonomous ships and/or maritime security and should include information on training programs and resources. The exclusion criteria were that the studies should not be relevant to the research question or should be duplicates of other studies.

Data Extraction and Analysis

The studies that met the inclusion criteria were reviewed in depth to extract relevant information on training programs and resources for autonomous ships and maritime security. The extracted information was organized into themes and analyzed to identify gaps in training programs and resources, and to make recommendations for improving training programs and enhancing maritime security.

The analysis of the studies was conducted using a content analysis approach. This involved organizing the extracted information into categories and themes and identifying patterns and trends in the data. The analysis also involved comparing the findings of different studies to identify areas of agreement and disagreement.

RESULTS AND DISCUSSION

While searching the literature, a total of 58 papers that qualified for inclusion were discovered. The studies were published between the years 2010 and 2021, and they addressed a broad variety of subjects connected to the education of crew members aboard autonomous ships and the protection of maritime infrastructure. The studies were assessed using a method known as content analysis, and the findings are summarized in the following paragraphs.

Training Programs and Resources for Autonomous Ships

The studies that were looked through brought to light the significance of having efficient training programs and resources for autonomous ships (Komianos, 2018). The following are some of the most important topics that should be taught in training programs:

- Navigation and operation of ships operating on their own,
- Performing service and repairs on unmanned

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vessels,

- Risk assessment and management,
- Preparedness for unexpected events and responses to emergencies, and
- Collaboration and open lines of communication

There are several resources that need to be made accessible to assist training programs. These resources include simulators, training manuals and materials, and access to experienced staff.

Based on the findings of the examined research, it has been identified that Egypt's training programs and resources for autonomous ships exhibit some deficiencies. A lack of comprehensive and current training programs was one of these gaps, as was a lack of coordination amongst stakeholders in the formulation and execution of training programs and a lack of funding for training programs (Gouda, 2016). According to the research, training programs should be designed to address these gaps, and resources should be made available to assist the creation and implementation of these training programs. The studies also advised that these training programs be produced.

Table I. Summary of Training Programs and Resources for Autonomous Ships

Theme	Description	Gaps	Recommendations
Training Programs	Navigation and operation of autonomous ships, maintenance and repair, risk assessment and management, emergency response and contingency planning, and communication and teamwork	Lack of comprehensive and up-to-date training programs, lack of coordination between stakeholders and lack of resources	Develop comprehensive and up-to-date training programs, coordinate the development and implementation of training programs between stakeholders, provide resources for training programs
Resources	Simulators, training manuals and materials, access to experienced personnel	Lack of resources	Provide resources to support the development and implementation of training programs

Cyber Security

Cyber security was another topic that was brought up in the research, and it emphasized how important it is for autonomous ships and marine safety (Bolbot et al., 2020; Sharma and Kim, 2022). In addition, autonomous ships face a number of cyber security vulnerabilities, including the following:

- Unauthorized access to the ship's databases and computer systems,
- Malware and viruses,
- Attacks that deny access to a service, and
- Attacks using spoofing and phishing techniques.

Based on the findings of the investigations, it was advised that training programs for autonomous ships should include cyber security training, and that resources should be made available to assist cyber security training. Furthermore, the regulatory framework for autonomous ships must be expanded to incorporate provisions for cyber security.

Table II. Summary of Cyber Security

Theme	Description	Recommendations
Cyber security	Unauthorized access to the ship's systems and data, malware and viruses, denial of service attacks, spoofing and phishing attacks	Integrate cyber security into training programs, provide resources to support cyber security training, include cyber security in the regulatory framework

Coordination and Collaboration

According to the studies that were analyzed, coordination and cooperation among the many stakeholders is essential for the creation and execution of training programs and resources for autonomous ships as well as maritime security (Ichimura, 2021; Tijan et al., 2021). There are a number of different parties that ought to have a say in the development of training programs and resources. These parties include ship-owners, ship operators, training providers, and regulatory bodies.

Additionally, there is also a need for coordination and cooperation among the many stakeholders in the process of developing and implementing training programs and resources. According to the findings of the research, the various stakeholders should collaborate in order to design comprehensive and current educational programs and resources that are adapted to meet the particular requirements of the ship and the members of its crew.

Table III. Summary of Coordination and Collaboration

Theme	Description	Recommendations
Coordination and Collaboration	Involvement of ship-owners, ship operators, training providers, regulatory authorities, as well as coordination and collaboration between stakeholders.	Create a systematic communication strategy that includes frequent meetings, conferences, and information sharing sessions for all parties involved in order to establish regular communication channels. This will improve cooperation by facilitating the sharing of ideas, updates, and comments.

Regulatory Framework

The relevance of the regulatory framework for autonomous ships and maritime security was also stressed in the papers that were evaluated (Komianos, 2018; Li and Fung, 2019; Mallam et al., 2020). There are various regulatory problems that need to be fixed, including the following:

- The establishment of certification and guidelines for autonomous ships,
- Insurance and legal responsibility,
- Regulatory frameworks for cyber security, and
- Cooperation and coordination on the international level.

A complete regulatory framework that tackles these challenges and gives direction for the design and operation of autonomous ships should be devised.

Table IV: Summary of Regulatory Framework

Theme	Description	Recommendations
Regulatory Framework	Certification and standards for autonomous ships, liability and insurance, cyber security regulations, international cooperation, and coordination.	Need for a comprehensive regulatory framework.

Automation in the Navy

Since World War one, the navy has incorporated automation. The majority of modern naval ships are highly automated, according to recent studies by Barrett et al. (2019) and Cordle & Cotter (2019). The automation adoption in the navy has had both favorable and unfavorable effects. It was stated that better communication between designers of automation systems and navy personnel currently in service will help to offset these negative consequences by reducing the likelihood of the introduction of automation systems that are ineffective for their intended use. Prior to their deployment on autonomous ships, new recruits, and existing serving naval officers have focused on receiving adequate training, as their arrival frequently results in the reallocation of functions. The serving personnel transition training is essential before their deployment in highly automated littoral warfare ships, according to Cordle & Cotter's (2019) suggestion. Additionally, Barrett et al. (2019) argue in favor of preparing autonomous ships brand-new naval recruits.

Autonomy, which means independence and self-governance in Greek, is derived from the terms "auto" and "nomos," which both imply law. So, in a strict sense, an autonomous system is one that has the capacity to change the predetermined, programmed course of action that the system's inventor has established. A former executive of Ford Motor Company created the word automation, which was derived from autonomy. The phrase automation was conceptualized as "the execution by a machine agent (typically a computer) of a function that was previously performed by a human" in the literature, which is where it first appeared. These authors assert that a function no longer qualifies as automation when it has been fully and permanently transferred from a human to a machine. According to this definition, an autonomous system is one that is incapable of deviating from its pre-programmed operations (Vagia et al., 2016).

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According to Man et al.'s (2015) study, which primarily focuses on human factor issues linked to the ships operation from shore control centers (SCCs), future SCC operators would need training in terms of their cognitive skills to appropriately handle every information displayed on screens in SCCs. Man et al. (2015) fell short of going farther and putting out any framework for the improvement of cognitive abilities of future ship operators from SCCs. The other studies stress the necessity of coordinating seafarers' training with technical advancements in MASS, but they do not precisely describe the kind of training that will be required or suggest a structure for enhancing seafarers' future skill sets. However, Nguyen (2018)'s survey of maritime experts indicates that future seafarer training would prioritize:

- Computer-depending and Simulator-depending training,
- The Virtual Reality technology and simulation use, which also permits to seafarers to practice and train on board,
- Personalized training that is absolutely tailored to the individual requirements,
- Competencies of STEM (engineering, technology, science, and math) introduced for all technical industries,
- Recent knowledge in managing people and leadership, associated with management in the sector,
- The young seafarers' Preparation for life at sea, and
- Training those who, as marine engineers, port officers, or electro-technicians, will operate future autonomous ships and their propulsion systems either remotely or onboard.

The characteristics of the sailors who will man the ships of the future imply that they may have both non-seafaring and seafaring backgrounds. Future mariners will be trained using simulations extensively. The precise facilities that will be required for training upcoming ship operators are still mostly unknown (Mallam et al., 2020).

Resource Unavailability leads to Piracy

Maritime piracy, which is fundamentally a kind of illegal behavior, differs from other forms of criminal activity since it happens in areas of the high seas outside of any nation's territorial authority. Piracy flourishes in lawless areas. This lack of effective government and unrestrained natural resource exploitation, notably energy and fisheries, hurts the economy. Somalia is the most famous example of how failing fisheries and coastal ecosystems have fueled piracy. Foreign fishing fleets with bigger, more effective ships and operations drove Somali fishermen out of the richest fishing grounds. The fishermen joined together with local militias, who filled the governance void, in order to engage in ship hijacking for ransom since they were facing the loss of their livelihood and the absence of an efficient administration to deal with foreign incursions (Kantharia, 2019).

Military or maritime law enforcement power can be used to combat piracy in the short term, but this tactic only offers temporary relief to crews and ships and does not address the deeper, systemic problems that support piracy. As an illustration, consider the international naval forces deployment to the Horn of Africa to protect commercial ships and quell piracy. Since the roots of piracy are not being properly addressed, the effect over time decreased the shipping attacks, but the withdrawal of those naval forces is likely to lead to a revival of piracy. In order to address these root causes and systemic problems, it is important to strengthen the law rule, provide viable economic alternatives to piracy, and ensure that international assistance is delivered in a targeted and efficient manner (Jin and Techera, 2021).

Focus on Cargo Security Enhancement

The ISPS Code introduction has significantly, though not solely, shaped the focus on vessel and port security since September 11, 2001, or 9/11, when terrorists launched coordinated assaults against the US. In the future, port and vessel security will probably move to a focus on ships and ports as conduits within the supply chain rather than as targets due to the sustained and anticipated maximization in the volume of global cargo and the concentration on "Just-in-Time" delivery of commodities. This is a result of growing concern over the secure and safe transportation of commodities. "Just-in-Time" delivery is a supply chain idea to lessen the need for cargo warehousing and storage. There may also be fewer "moves" inside a supply chain in some circumstances, which eliminates some transfers across logistics providers. Although the idea is meant to cut costs, the fact that it depends on on-time deliveries makes supply chains more susceptible to disruption.

The following are some of the elements that will aid in the transition from vessel and port security to cargo and supply chain security:

- The ISPS Code clearly defines the criteria for port and ship security, although the Code concentrates on ports and ships as terrorist aims rather than as hubs for nefarious activities, cargo theft, or the contraband flow, including the Weapons of Mass Destruction potential introduction;

- There is more cargo in the system since global trade keeps growing extremely quickly;
- The global supply chain is becoming more and more dependent on "Just-in-Time" delivery, which increases its sensitivity to disruption and the potential severity of its effects; and
- Large volumes of personal, financial, and freight information are also progressively flowing digitally, which raises the possibility of integrated security concerns (Physical, cyber, and operational).

The ISPS Limitations (Edgerton, 2021)

Following the 9/11 terrorist attacks, the ISPS Code was created and went into effect globally in 2004. The Code was created with an emphasis on preventing attacks of terrorist on ships and ports rather than on the ships and ports use as conduits for illicit activities, contraband, or people since at the time, protecting essential infrastructure was a top priority. Access some cargo and control-related issues were addressed, but little attention was paid to cargo security. (CBP) US Customs and Border Protection launched new initiatives to focus on cargo security, including the placement of CBP personnel at the busiest container ports worldwide, under the auspices of the US container security initiative (CSI), to act as liaisons and coordinate the screening of cargo headed for the US in addition to the expansion of voluntary, incentivized programs of cargo security like Customs-Trade Partnership Against Terrorism, which the US implements.

Furthermore, the ISPS code did not specifically address cyber security because it was introduced prior to the rapid improvements on the internet, information technology, and the shipping sector. Although the Code mentions information protection, it imposes no rules or criteria for it.

The ISPS Code is therefore not intended to adequately address issues of cargo security and developing cyber security difficulties specific to the industry, despite the fact that it is still current and very successful at defending ships and ports from assault.

While this literature review has provided valuable insights into the training programs and resources for autonomous ships and maritime security in Egypt, there are several limitations that should be acknowledged as follows:

1. Limited research on autonomous ships in Egypt,
2. Limited information on the effectiveness of training programs,
3. Limited information on the costs of training programs,
4. Limited information on the impact of autonomous ships on maritime security,
5. Limited information on the regulatory framework for autonomous ships in Egypt,
6. Limited research on the integration of cyber security into training programs, and
7. Limited focus on small-scale autonomous ships.

CONCLUSION

The development of autonomous ships has the potential to completely transform the shipping sector, but at the same time, it presents a number of important issues for maritime education and safety. The purpose of this literature review was to investigate the previous research that has been conducted on the subject of training for autonomous ships and maritime security, with a particular emphasis on Egypt. The goal of the assessment was to identify any gaps in training programs and resources and to give suggestions for strengthening training programs and increasing maritime security in Egypt. Specifically, the evaluation focused on Egypt's maritime security.

Following the evaluation, many important topics were recognized as ones that need to be included in training programs. These include the navigation and operation of autonomous ships, maintenance and repair, risk assessment and management, emergency response and contingency planning, as well as communication and collaboration. The evaluation determined that several resources, including simulators, training manuals and materials, and access to experienced staff, should be made accessible to assist training programs.

Accordingly, there are a few deficiencies in the training programs and resources available for autonomous ships in Egypt. These deficiencies include a lack of comprehensive and current training programs, a lack of coordination between stakeholders in the development and implementation of training programs, and a lack of resources for training programs. This evaluation makes a number of recommendations, one of which is that training programs that address these gaps should be established, and that resources should be made available to assist the creation and implementation of these training programs.

In addition, the evaluation emphasizes the significance of cyber security, coordination, and teamwork, as well as the legislative framework for autonomous ships and marine safety. It is recommended that training programs for autonomous ships should include cyber security

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training, and that resources should be made available to assist cyber security training. The study concludes with the recommendation that the regulatory framework for autonomous ships should include cyber security considerations. In addition, the assessment highlights the significance of coordination and cooperation among the many stakeholders in the process of developing and implementing training programs and resources for autonomous ships as well as maritime security. Based on the findings of the study, the stakeholders should collaborate in order to establish training programs and resources that are both thorough and up to date, as well as resources that are suited to the particular requirements of the ship and its crew. In conclusion, the study emphasizes how important it is to have a legal framework in place for autonomous ships and to maintain maritime safety. A complete regulatory framework is recommended to be constructed as a result of the evaluation. This framework should handle problems such as certification and standards for autonomous ships, liability and insurance, cyber security rules, as well as international collaboration and coordination.

RECOMMENDATIONS

Based on the findings of this evaluation of the relevant literature, a number of suggestions are available for the creation of educational programs and resources pertaining to autonomous ships and maritime security in Egypt, including the following:

- Create instructive programs that are both thorough and up to date,
- Make available resources for educational program,
- There is a need for coordination between various stakeholders in the process of developing and implementing training program, and
- Cyber security education should be included in educational programs for ships that operate on their own. Training in cyber security needs to be supported by resources that ought to be made accessible. It should also be included into the regulatory framework for autonomous ships, and finally
- Create an all-encompassing regulatory structure.

LIMITATIONS

This literature review is based on research that was published in English; thus, it is possible that relevant studies that were published in other languages were not included in the study. This is one of the limitations of the review. In addition, the review was restricted to research that was published between the years 2015 and 2022, therefore it is possible that some pertinent studies were missed. In addition, the study was restricted to just electronic resources, therefore it is possible that pertinent research that was not indexed in these databases was overlooked.

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