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Benefits and Challenges of Autonomous Vessel Use on the Shipping Industry

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Abstract

Each year about 90% of the global trade is carried by sea. Furthermore, maritime transport is the only option for the movement of large volume cargo among continents. Shipping industry is essential for the global economy. However, this old business is now facing economic, environmental, and social challenges. Traditional technical or operational solutions, such as building larger ships or slow steaming, have reached their limitations to overcome various problems. The new generation of technology, such as autonomous vessels, is believed to be a potential cure for the difficulties faced by the shipping industry. there is a lack of published studies related to artificial intelligence and autonomous ships, So the aim of this study to prove that there are potential economic and environmental benefits associated with the implementation of autonomous vessels. The study combined the qualitative and quantitative approaches. The quantitative data were collected using a survey whereas the qualitative aspects were done through analyzing the literature and concluded this section with SWOT analysis. The value of this study to highlight the benefits and challenges of Autonomous Vessel Use on the Shipping Industry

Keywords: Autonomous, Maritime, Transport, Vehicles.

1. Introduction

The transportation sector is becoming increasingly multidimensional and sophisticated as a result of technological advancements, providing both difficulties and opportunities. These new technologies allow for increased safety, less emissions, lower costs, and more productivity. Autonomous technology has risen to the forefront in recent years, not just in the shipping industry, but in the transportation sector as a whole. The International Maritime Organization (IMO) of the United Nations (UN) is now conducting scoping exercises to assess the safety, environmental. Different types of autonomous technologies have been applied and integrated into our transport systems in the past decades. Today, with a technological breakthrough in areas such as artificial intelligence (AI), driverless or fully autonomous transportation is no longer just a dream but a reality on certain transport legs. For road transport, the concept of autonomous cars is being developed and tested by companies like Google and Tesla (Tesla, 2018). For air-based transport, unmanned aerial vehicles (UAVs) or drones are also being introduced for delivery services (Amazon, 2018) , as for types of marine crafts, this review paper considers vessel, ship, and surface vehicle., and

security issues of operating Maritime Autonomous Surface Ships (MASS). The advent of autonomous ships that are unmanned or low-manned will reduce the number of people at risk at sea. Even when autonomous navigation does not reduce the number of accidents, this means that safety at sea will increase.

Therefore, this research paper will verify the potentiality of autonomous ships through different aspects. This study will precisely focus on the main factors that affect on the autonomous ships industry.

This paper has been prorated in a total of five sections. Section 1 of the paper is the introductory phase, which shed the lights on this new technology in the shipping industry. Section 2 literature review on factors that have an impact on the autonomous ships such as environmental, economic, legal and logistics aspects. Section 3 is explaining the methodology of data collection using mixed approaches and showing the analysis techniques and concluded with SWOT analysis. Section 4 the discussion and findings are presented. Finally, the study concludes with a summary of further research work.

2. Literature Review

The commercial industry is predicted to have the greatest market share throughout the forecast period, based on application. Trends show two sides of the same coin: as ships become larger, corporations aim for economies of scale. Rising tourism and income impacts have a positive impact on the expansion of this category. According to UNCTAD, this is a favorable trend for the recovery of global trade because there is no lack of carrying capacity and trade costs continue to fall in the long run. For examples, throughout economics, Greece remained the world's leading ship-owning country, with Greek businesses accounting for more than 16% of the global industry, followed by companies from Japan, China, Germany, and Singapore. Fully autonomous vehicles are also expected to promote market growth in Autonomy.

There are various advantages with using autonomous vessels, including a reduction in the probability of marine accidents, which would improve safety. For example, using technology, it will be possible to monitor hull stress in extreme weather conditions and offer actual info on a vessel's mechanical stability. Human error is currently responsible for 75 to 96 percent of maritime incidents. (Morrow,2018) When contemplating the operation of MASS, several considerations must be considered, including accountability and safety. The need to build a legal framework that considers ship operation in semi-autonomous and completely autonomous settings will be a huge

problem, not just for humanitarian activities. The IMO's MSC announced a regulatory scoping experiment in May 2018 at their 99th meeting, analyzing the most appropriate strategy to address MASS operations, taking into consideration the human element, technology, and operational factors (IMO, 2018). A research project by MUNIN (Maritime Unmanned Navigation through Intelligence in Networks) predicted a saving of over \$7m over a 25-year period per autonomous vessel in fuel consumption and crew supplies and salaries.

Table 1: Summary of literature review.

#	Paper focus	Title	Description	Author(s)
1.	Impact of autonomous ships on shipping industry	The Impact of Autonomous Ships on Safety at Sea – A Statistical Analysis	This study focusses on the distribution of human casualties and lost ships over accident types and ship types.	Jiri de Vos et al., (2021)
2.	Using of autonomous ships in winter-time conditions in Greenland and measured bathymetry and ocean currents.	An affordable and portable autonomous surface vehicle with obstacle avoidance for coastal ocean monitoring	This paper described the design, construction, and validation of the Arctic Research Centre Autonomous Boat.	Daniel F. al., (2019)
3.	Impact of autonomous ships on the economic gross.	Analyzing the economic benefit of unmanned autonomous ships: An exploratory cost-comparison between an autonomous and a conventional bulk carrier	Impact of applying autonomous ships on the economic benefits.	Lutz Kretschmann, (2017)
4.	Analyzing of Autonomous shipping	SWOT-AHP ANALYSIS OF AUTONOMOUS SHIPPING	propose a detailed autonomous shipping strategy based on SWOT-AHP analysis.	Yunus et al., (2017)
5.	Effect of this new technology on maritime transportation	Towards the assessment of potentiality of unmanned vessels on maritime transportation safety	Assess whether the accident would have happened if the ship had been unmanned	KrzysztofWróbel et al., (2017)

As the literature in this category is relatively recent and limited, that foresee that important research about how autonomous ships will impact logistics and transportation is still to come. From this point research gap has been appeared there is lack in the literature related to the autonomous vessels because it's a new trend. so this research will add to the literature through investigating the benefits and threats of this new technology, moreover compare between the autonomous ships and traditional ships through the main factors extracted from the literature review. As shown in Table 1, a review of previous studies. So, the following section (Research Methodology) will explain the methodology of data collection using mixed approaches and showing the analysis techniques and concluded with SWOT analysis.

3. Research Methodology

This research conducted a comparative approach as a research methodology, the researchers compare between two different kinds of ships, one of them traditional ships which is the common kind for stakeholders, while autonomous ships are a new technology in the shipping industry.

The study applied mixed methods approach of both qualitative and quantitative data. The quantitative data were used to analyze the impact of applying this technology and to verify the main benefits and obstacles that have an effect on it using the cross-sectional survey developed by the authors. the survey has included many aspects such as the familiarity of participants with the concept, their opinion about the technology, their opinion about the current performance versus the expected performance with automation, the expected user's willingness for adapting with the technology, the control over the autonomous ships, the government actions, the expected profit, the environmental impact and the safety concerns, the researchers published it online to facilitate data collection from selected respondents (stakeholders) .

On the other hand, the qualitative aspects have adopted to understand the impacts of the autonomous ships on the transportation sector in order to analyze and investigate the main aspects that have an impact on applying this new technology and its consequences. Whereas the qualitative data were gathered from rich and extensive literature such as; research journal articles and conference papers, in addition to the reports and documents from the local and international bodies like IMO, UNCTAD. The following section will illustrate in details the analysis and results of this survey.

4. Results & Discussion.

4.1 Human Failure

The operator's lack of situational awareness, inability to properly assess data provided by multiple sensors and insufficient perception of actual hydro-meteorological conditions along with their effect on ship's behavior. Some issues of data misinterpretation by unmanned vehicle's operators are well-known to military personnel involved in airborne drone operations, therefore such hazard needs to be anticipated at the planning stage of the unmanned ships operations.

4.1.1 Traditional ships human failure

A large number of errors that happens in the maritime transport are happening due to human failure, by reducing the human intervention and depending on autonomous ships it is expected to significantly reduce the potential accidents.

4.2 Shipping Accident

Table 2: A summary of the evaluation of different scenarios.

Scenario	Percentage of the fleet that is affected	Reduction in ship losses		Reduction in lives lost	
		Percentage	Ships saved per year	Percentage	Lives saved per year
Empty Cell					
1 – small cargo ships become unmanned	23%	n/a	n/a	47.4%	83
2 – all cargo ships become unmanned	50%	n/a	n/a	69.5%	121
3 – all ships become unmanned	100%	n/a	n/a	100%	174
4 – reduced number of accidents for small cargo ships	23%	0% – 14.2%	0 – 13	0% – 12.8%	0 – 22
5 – reduced number of accidents for cargo ships	50%	0% – 20.8%	0 – 19	0% – 15.7%	0 – 27
6 – reduced number of accidents for all ships	100%	0% – 29.8%	0 – 27	0% – 20.8%	0 – 36

As shown in table1, The actual benefit that can be associated with this scenario depends on the percentage of navigation-related accidents that can be prevented by automation. A reduction of 0% will, obviously, result in no reduction in ship losses or lives lost. A reduction of 100% will lead to the reductions as mentioned above. Any other reduction in navigation-related accidents between 0% and 100% will result in a corresponding reduction in ship losses and lives lost. As an example, a reduction of 50% in navigation-related accidents, will result in a reduction of 7.1% in ship losses.

4.2.1 Traditional ships shipping accidents

The occurrence of shipping accidents has many reasons, large number of accidents happens as a result of human errors and negligent mistakes.

4.3 Laws and regulations

The existing maritime laws do not offer a practical legal framework for autonomous vessels to operate in international waters. (Hogg, T., Ghosh, S, 2016) Argue that such incompleteness in law and regulation has become one of the main obstacles for the development of autonomous ships and therefore need to be fixed.

4.3.1 Traditional ships laws and regulations

A regulatory framework for shipping industry exists that is governed by the international maritime organization IMO. It is a global authority for the safety, security and environmental performance of international shipping.

4.4 Environmental impact

Shipping is one of the major sources for different types of emissions, for example, CO₂, SO_x, and NO_x. The literature about emission reduction for the conventional ships is well developed. However, only few articles collected in this survey considered the environmental impact brought by autonomous vessels. (Hogg, T., Ghosh, S, 2016) And (Rolls-Royce, 2018) briefly discussed the potential emission reduction due to higher energy efficiency of unmanned ships.

4.4.1 Traditional ships environmental impact

Traditional shipping has a negative impact on the environment that includes: air pollution, water pollution, acoustic, and oil pollution.

4.5 Transportation and logistics

According to (Rolls-Royce, 2018) Discussed how the autonomous vessel will redefine the entire shipping industry. New business relationships and networks, as well as new actors and their roles are the main drivers for this transition. (Danish Maritime Authority, 2016) Proposed many ideas about potential application of autonomous vessels, for instance island ferries for rural areas, service vessels for offshore operations, and tugboats in port. (Zhu,et., 2016) Presented a real-world application of USVs collecting maritime traffic information to facilitate the judgment and decision regarding another vessels' navigation.

In accordance to the previous five variables, a comparative analysis was conducted between autonomous ships and traditional ships in order to assess the compatibility with these variables. The criteria for comparison includes: human failure, shipping accidents, laws and regulations, environmental impact and transportation and logistics.

Table 3: A comparative analysis of autonomous ships and traditional ships.

	Autonomous ships	Traditional ships
human failure	It is anticipated that Ship turn out to be completely unmanned, but autonomy has no impact on number of accidents. And that autonomy decreases number of navigation- related accidents when there is a substantial reduction in crewing level. (de vos, 2021)	The total percentage of accidents attributable to human error, adding up the errors of crews plus those not attributable to the crew, is 75% (Beaskoetxea,2021)
shipping accidents	A study has showed that the reliance on autonomous ships tends to decrease the quantity of ships on cargo ships by 50%. All cargo ships will become unmanned because of the implementation of autonomous systems. the conclusion of this scenario will further reduce the quantity of lives lost confounded, to a complete reduction of 69.5%. (De Klerk, 2019)	According to Allianz annual review of trends and developments in shipping losses and safety 26000 shipping accidents had occurred over the past decade as a results of the reliance on the normal shipping. the most cause behind the accidents is that the machinery damage. And a complete of 876 vessels were lost within the period of 2011-2020. (Allianz, 2021)

laws and regulations	The USA incorporates a very complicated system of legislation that's applicable to autonomous vehicle. it's non-binding federal legal framework. The US Department of Transportation with the National Highway Traffic Safety Administration (NHTSA) have developed the Federal Automated Vehicles Policy ⁷ to determine a normative base at a federal level. The Policy contains not only recommendations for car manufacturers and software companies but also acts as a guide for state legislator (Part "Model State Policy"). It covers plenty of various aspects of autonomous driving from safety to cybersecurity. Although the foundations launched within the manual don't seem to be legally binding, manufacturers and software companies follow them to avoid being answerable for negligence just in case of a test crash. (Dremluiga, 2020)	Common potential gaps and themes identified across several safety treaties associated with provisions containing manual operations and alarms on the bridge; provisions associated with actions by personnel (such as firefighting, cargoes stowage and securing and maintenance); watch keeping; implications for search and rescue; and knowledge required to get on board for safe operation. (IMO, 2021)
environmental impact	There exist a significant reduction of pollution by ships. This is primarily due to the absence of crew on board. This absence means that, for example, no garbage or sewage is produced inside the ship. (Zanella, 2020)	Regarding oil pollution, it's important to notice that this pollution from ships occurs in two main ways: first, as a results of maritime accidents that cause the spillage of huge amounts of oil into the sea; and secondly, through operational discharges of the waste generated by the vessels, which involve the insertion of pollutants in smaller, but cumulatively significant quantities.
transportation and logistics	the adoption of autonomous ships tend to incorporate reduced operational, voyage and crew costs; increased safety of operations; and earning potential from new vessel designs. The potential to integrate autonomous ships within the Internet of Things (IoT) within logistics and provide chains is yet one more foundation of potential benefits. (Tsvetkova, 2022)	It is expected to find a longer travel distance in traditional ships over the autonomous ships. Which makes the reliance in autonomous ships increasing the logistics performance and cut down the voyage time. (Gu, 2021)

After analyzing the questionnaire, several effects were identified and summarized as follows:

Strengths

- Elimination of human error.
- Reduced crewing costs.
- Increase the safety of life.
- Allow for more efficient use of space in ship design and efficient use of fuel.
- Prevent accidents due to technology failures (e.g. navigation system, sensor module)

Weaknesses

- Large capital expenditure in initially investing in the technology.
- Obstacles is setting-up the onshore operations to monitor fleet movements.
- The possibility of incompatibilities between the current marine infrastructure and an unmanned vessel.
- Lack of crew will make maintenance of moving parts incredibly difficult on long voyages and breakdowns could result in significant delays.

Opportunities

- Enhanced attractiveness of working in the maritime industry.
- Reduced environmental footprint of shipping.
- Increased maritime security.
- Prevention of predicted future shortage of sea-going personnel.
- Less maritime accidents (collisions).
- Higher profitability of shipping companies.
- Higher safety of life at sea.
- Lower maritime transport cost.
- Transfer of developed innovative technologies to manned ships .
- New innovative ship designs.
- Increased concerns about the environmental protection.

Threats

- Adapt maritime legislation for unmanned ships are still unknown.
- Ensure safe interaction of autonomous and conventional ships.
- Cyber-attacks by terrorist.
- Difficulty in guaranteeing safe operation in harsh weather conditions.
- Develop maintenance strategies in the absence of personnel on board.
- Ensure reliable satellite communication between ship and shore.
- Ensure high quality maritime personnel in future.
- Prevent unlawful boarding by unauthorized persons.

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