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LIABILITY IN COLLISIONS INVOLVING AUTONOMOUS SHIPS: LEGAL CHALLENGES AND TECHNOLOGICAL ACCOUNTABILITY

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ABSTRACT

The introduction of autonomous ships is dynamically changing the maritime industry as it presents major legal challenges in determining the liability for collisions. The traditional naval which includes the UNCLOS and COLREGS are based on the human-operated vessels which further creates significant gaps and uncertainties when applied it is applied to autonomous technology. This research is written to explore the complexities of assigning liability in collisions that involve autonomous ships which focuses on the roles of the ship-owners, operators, technology developers, and the manufacturers.

The key finding in this research paper depicts that the current legal framework is struggling to acknowledge the attribution of fault caused by incidents that involves the complex autonomous systems. Further, the black-box nature of these systems complicates the process of evidence-gathering and the decision-making process. The case studies analyzed in this research paper illustrate the practical challenges that occurred in the court when it comes to determining liability and highlight the urgent need for legal reforms.

This research paper recommends reforming the UNCLOS and COLREGS to incorporate the provisions mainly for autonomous ships as they include the defining of the legal responsibilities of the autonomous systems and their respective operators. This research paper also suggests developing a new liability framework that balances traditional negligence with the accountability of the technology provider. In addition to this, even the importance of international regulatory harmonization is emphasized to ensure proper consistency of the legal standards globally.

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Finally, this study concludes by emphasizing that adapting the maritime law to acknowledge the unique challenges possessed by the autonomous ships is very essential for promoting the safety, accountability, and the seamless merger of the autonomous technology into the maritime operations. At last, this research paper recommends areas such as cyber security, ethical considerations, and evidence protocols for the autonomous maritime incidents that occur.

INTRODUCTION

The introduction of autonomous ship technology brought a drastic change in the maritime sector, bringing up various advancements in AI, robotics, and sensor technology. These objects can operate with less or zero human intervention which promises to increase the efficiency, safety, and effectiveness in cost reduction in shipping operations. A major accomplishment in the technological revolution which also includes the intro of semi-autonomous navigation systems, full-scale trails of unmanned vessels, and the discussions headed by IMO. The change to autonomous shipping is coupled with the efforts for the reduction of human errors. Contrastingly, the innovation also possesses major complex legal and operational problems mainly in liability when collisions occur.

As autonomous ships started to navigate in the international waters through this the major question of liability in the event of maritime collusion had become increasingly vital. The traditional maritime laws are based on the human-operated vessels which does not properly acknowledge the unexpected circumstances possessed by the autonomous technology.
Finding out faults in the collisions that involve autonomous ships requires a proper and thorough re-valuation of the preset legal principles, considering factors like the role of the technology developers and further the ship operators and the effectiveness of the autonomous systems. Acknowledging the liability is very essential not only to ensuring accountability but also to foster the trust and ensure proper safety in autonomous maritime operations.

The main aim of writing this research paper is to navigate through all the legal challenges and gaps present in the current maritime laws which are concerned with the liability in collisions that involve autonomous ships. The study aims to analyse how the present legal framework like the UNCLOS and COLREGS shall apply to autonomous ships. Furthermore, the research paper is written to

give logical solutions to this topic and finally, the research paper proposes the legal reforms for the issue.

1. LEGAL FRAMEWORK FOR MARITIME LIABILITY

1.1 OVERVIEW OF TRADITIONAL MARITIME LIABILITY LAWS

The age-old maritime liability laws are mainly based on the fault and negligence principles. In all the collision cases the liabilities are usually assigned to the respective parties liable for the incidents which are frequently determined by their un-successfulness the comply with the navigational standards[2].

Maritime laws like UNCLOS and many other international conventions govern the allotment of the fault, compensation for the damages, and provide the resolution for the disputes. The common law doctrines such as the limitations of the liability enable the shipowners to decrease their financial responsibility. The age-old legal rules are created for human-operated vessels which usually depend majorly on the evidence of human errors like the failures to maintain good proper lookout. Furthermore, the intro of autonomous ships raises various questions regarding how the laws apply when the human involvement is very less which further brings a necessity for an adoption of the existing liability principles to allot new techno reality[3].

1.2 UNCLOS PROVISIONS RELEVANT TO COLLISION LIABILITY

The UNCLOS provides a greater legal framework for maritime activities which includes the provisions relating to the collision liability. Article 94 of UNCLOS major speaks about the duties of flag states which ensures that their vessels operate in compliance with international regulations which includes safety at sea[4]. Additionally, the UNCLOS regulates compliance with the navigation rules provided by the IMO like the COLREGS to prevent collisions.

[2] *The Limitation of Liability Act* (1924)
[3] Tetley, W. (2003). *International Maritime and Admiralty Law: Legal Principles and Practice*
[4] Article 94 of the United Nations Convention on the Law of the Sea (UNCLOS)

Furthermore, regarding collisions article 97 speaks about the criminal jurisdiction of flag states which mainly emphasizes the legal proceedings which shall be majorly conducted in the respective state jurisdiction[5]. While the UNCLOS frames down a functional structure for safeguarding collisions which does not specifically acknowledge the complexities brought by the autonomous ships it prompts the need for further legal development to be merged in the emerging technology.

1.3 INTERNATIONAL REGULATIONS FOR PREVENTING COLLISIONS AT SEA (COLREGS)

The COLREGS provides the standardized navigational framework that aims to prevent maritime collisions which is adopted by IMO[6], these frameworks provide a sketch for the responsibility of the vessels to avoid collisions maintain a proper structure that adheres to the safe speeds, and properly follow specific conduct in the various present sea conditions and the traffic conditions.

The COLGRES also lays down the definition of rules of the road for the vessels which details the actions to be taken when the vessels encounter each other to avoid collisions. While the COLREGS are created for human-operated vessels the rise of autonomous ships poses significant challenges in applying the rules mainly relating to the interpretation of proper lookout and the proper decision-making in collision avoidance which necessitates updates to the regulations to account for the autonomous navigation systems.

2. AUTONOMOUS SHIPS AND EXISTING LEGAL CHALLENGES

2.1 DEFINITION AND CLASSIFICATION OF AUTONOMOUS SHIPS

Autonomous ships are vessels that are equipped with advanced technologies that allow them to operate with various degrees of human intervention[7]. The classification of this is based on the level of their autonomy and they are categorized in 4 levels.

[5] Article 97 of the United Nations Convention on the Law of the Sea (UNCLOS)
[6] International Regulations for Preventing Collisions at Sea (COLREGs), 1972
[7] Schaub, M., & Hafner, M. (2020). "Autonomous Ship Classification Systems and Legal Implications

These classifications usually help to distinguish the operational capabilities and technological sophistication of various autonomous vessels. The fully autonomous ships depend upon the AI, sensors, and effective communication systems to navigate make decisions, and properly respond to environmental conditions without any direct human control. The classification rules are very vital for understanding the technological and operational context of autonomous ships.

2.2 LEGAL RECOGNITION AND STATUS OF AUTONOMOUS SHIPS UNDER CURRENT MARITIME LAW

Under the present maritime laws, the legal recognition and the status of autonomous ships now also remain ambiguous. The Age-old maritime law which includes those set by the UNCLOS and IMO conventions assumes the presence of the human operates on the board[8] The key legal concepts like the master of the vessel and the needed requirement for human oversight in route navigation and safety are not easily applicable to autonomous ships.

In contrast, despite having successful advancements in tech most of the maritime legal rules have not advanced up to explicitly regulate the autonomous vessels. The lack of formal recognition leads to uncertainty mainly in terms of liability, registration, and operational requirements. Furthermore, because of autonomous ships currently are operating in a legal grey area which prompts calls for international rules to properly specify the legal conditions.

2.3 GAPS AND AMBIGUITIES IN APPLYING TRADITIONAL MARITIME LIABILITY FRAMEWORKS TO AUTONOMOUS VESSELS

The Traditional maritime liability frameworks are designed based on the assumptions of the human operations which creates many gaps and ambiguity when applied to the autonomous vessels. The key issues raised in determining the fault in the collisions as the present laws usually assign the liability based on the errors that occurred by the humans like the negligence caused in the navigation caused by the humans[9]. But complying with the autonomous ships the concepts are

[8] International Maritime Organization (IMO). (2019). *MASS Definitions and Levels of Autonomy*
[9] Legal Challenges of Autonomous Maritime Systems" (European Journal of Maritime Law, 2021)

very difficult to integrate as the decision-making is being complied with the complex algorithms and the AI rather than the human judgments.

Due to these decisions, various question arises about the responsibility of the technology developers, software providers, and the operators which further complicates the attribution of the fault. In addition to these factors, traditional concepts like seaworthiness and a proper lookout do not directly translate to autonomous operations which leads to uncertainty in the brief legal interpretation. All these legal gaps highlight the need for advanced intact legal rules that acknowledge all the possible unique challenges which is possessed by autonomous ship technology.

3. CASE STUDIES OF COLLISIONS INVOLVING AUTONOMOUS SHIPS

3.1 DETAILED EXAMINATION OF REAL OR HYPOTHETICAL CASE STUDIES

This section is written to examine the real or hypothetical case studies of the collisions which further investigate the autonomous ships and provide insightful information's in how such incidents are being handled in the current legal frameworks.

One of the hypothetical cases could involve a collision between a fully functional autonomous ship and a traditional vessel in congested waters. In this case, the autonomous ship's decisions-which are based on the algorithms and the sensor data would further be scrutinized to understand the cause of the collision[10].

Another hypothetical case involves partial human oversight where the remote operator's responsibility is being examined. So, by analysing both the case studies we could interpret the complexities of assigning the liability when the autonomous technologies are involved which highlights all the gaps in the present laws and the present possessable challenges in interpreting the age-old maritime principles for new introducible technologies.

[10] *MASS Trials: Lessons Learned* (IMO, 2021)

3.2 ANALYSIS OF HOW LIABILITY WAS DETERMINED OR COULD BE DETERMINED

In the cases which involve autonomous ships then the liability determination depends on the effective interpretation of the present legal rules.

For instance, a hypothetical situation, a collision happens then the courts would consider mostly whether the autonomous systems failed to comply with the navigational rules like the COLGRES and if there was any negligence present in designing the ship's design or the operation.

In a situation, if the human oversight is involved, the operators' actions or inaction could be scrutinized further. The liability can be shared between the ship owner and the technology developers and technology operators which reflects the multifaceted nature of responsibility[11]. The analysis reflects the need for clearer legal guidelines to acknowledge any unique aspects of autonomous technology.

3.3 INSIGHTS INTO THE PRACTICAL CHALLENGES FACED BY COURTS AND TRIBUNALS

The courts and the tribunals face many significant challenges when adjudicating cases involving autonomous ships. One of the major challenges is the lack of precedents and proper clearer standards for evaluating the actions of autonomous systems[12]. The judges must grapple with all the complex technical evidence which includes the algorithms, sensor data, and the decision-making process which may require expert testimony.

Another challenge is retributing faults among multiple parties like shipowners, operators, and technology developers. In addition to this, the global nature of maritime operations further complicates the jurisdictional issues as different countries may have varied legal solutions to the autonomous technology.

[11] *The Baltic Shipping Case* (1992)
[12] Lin, P., et al. (2019). *Liability and Ethics in Autonomous Technology*

4. TECHNOLOGICAL ACCOUNTABILITY

4.1 THE ROLE OF TECHNOLOGY DEVELOPERS, MANUFACTURERS, AND SOFTWARE PROVIDERS IN COLLISIONS

In collisions that involve autonomous ships, the technology developers and the software providers play a vital role as they design and implement the systems that usually control the vessels. The responsibilities also include ensuring the reliability, safety, and compliance of the autonomous systems with international maritime regulations.

For instance, collisions occur, so these entities will be scrutinized for potential defects in the design, coding errors, or inadequate system testing. Further, the involvement of the parties complicates the liability as the faults may not be raised from the traditional navigational errors[13]. Further, this raised various questions about the extent to which the developers and the manufacturers should be held accountable which is compared to the ship operators.

4.2 ISSUES OF FAULT ATTRIBUTION IN THE CONTEXT OF COMPLEX AUTONOMOUS SYSTEMS

The fault attribution of the collisions that involve autonomous systems is very complex, as the traditional concepts of the present negligence and human error are not directly applicable. The determination of liability involves assessing whether the autonomous system's decisions are reasonable and whether they are following the navigational rules.

This fault may be attributed to the shipowner for the improper system maintenance to the software providers for all the coding errors or to the manufacturers for any major defective components present in the ships[14]. The complexity of these systems makes it difficult to pinpoint the exact cause of the failure which leads to shared liability among the multiple parties.

[13] Hebert, C. (2020). *The Accountability Dilemma in Maritime Autonomous Ships*
[14] IMO's *Guidelines for Recording MASS Data*

4.3 DISCUSSION ON THE "BLACK BOX" PROBLEM AND EVIDENCE GATHERING

The most spoken topic is the “black box” problem in autonomous ships which refers to the difficulty in understanding the complex AI systems and effectively interpreting the decision-making process of the AI systems during the collisions. But unlike the human operators whose actions can be directly accessed, the internal workings of the autonomous systems are very opaque with the decisions taken by the algorithms and the sensor inputs[15]. The evidence gathered in such cases involves analysing all the data logs present, the sensor readings, and the system outputs to reconstruct the events.

However, the complexities and the proprietary nature of the systems hinder transparency and make the challenging for the courts to determine the exact reason for the incident and assign the fault effectively.

5. PROPOSALS FOR LEGAL REFORMS

5.1 RECOMMENDATIONS FOR UPDATING UNCLOS AND COLREGS TO ADDRESS AUTONOMOUS SHIPS

To acknowledge the rise of autonomous ships the UNCLOS and COLREGS need updates to explicitly merge the provisions for the vessels. The key recommendations which may, defining the legal status and the responsibilities of the autonomous ships like clarifying all the roles of all the remote operators or the autonomous systems are termed as the master of the vessels.

The COLREGS should be effectively amended to acknowledge the accounting for how the autonomous systems should interpret the navigational rules and properly respond to the dynamic maritime environment. The updates will provide proper and clear guidelines on the proper

[15] Bryson, J., et al. (2021). "Interpreting AI Decision-Making in High-Stakes Scenarios

compliance, liability, and operational standards which ensure the autonomous ships are effectively merged with the present legal framework.

5.2 SUGGESTIONS FOR NEW LIABILITY FRAMEWORKS OR AMENDMENTS TO EXISTING LAWS

The new liability framework should acknowledge the unique characteristics of the autonomous ships including the involvement of the technology developers, the manufacturers, and the operators.

The suggestion for inclusion includes adopting a strict liability approach for autonomous ships where the fault is presumed unless proven otherwise or creating a hybrid model that balances the traditional negligence principles with technological accountability.

These amendments may introduce a set of specific obligations for maintaining and updating the autonomous systems which ensures that they function safely and comply with the maritime regulations. The frameworks should help to clarify the liability and reduce the liability which reduces the legal uncertainties and promotes a safer deployment of the autonomous ships.

5.3 DISCUSSION ON THE POTENTIAL FOR INTERNATIONAL REGULATORY HARMONIZATION

International regulatory harmonization is essential for the effective governance of autonomous ships which as per given their global nature. The harmonized regulations will ensure consistency in the legal standards across all the jurisdictions which facilitates smoother international operations and find key solutions for reducing the conflicts in liability determination.

This requires collaboration with eminent maritime nations and international organizations like the IMO and the industry stakeholders to develop a uniform guideline. The challenges also include the balancing of the different national interests and the legal traditions but the potential benefits like increased legal clarity, improved safety, and facilitating technological innovations make the harmonization the crucial goal for the future of the maritime laws.

CONCLUSION

This research paper is written to highlight the significant challenges and the legal ambiguities surrounding the liability in maritime collisions that involve autonomous ships. The key findings indicate that traditional maritime laws like UNCLOS and COLREGS are not adequately attached to acknowledging the complexities brought by autonomous ships.

Furthermore, issues such as fault attribution, the role of technology, and developers, and the opacity of the autonomous decision-making systems further complicate the configuration of liability determination. This analysis reflects the need for reforming the present legal system to properly explain the status and the responsibilities of autonomous ships and to merge specific provisions for technological accountability.

The evolution of maritime liability law must prioritize adaptability and clarity to keep pace with the rapidness of technological advancements. International regulatory harmonization will be very essential to maintaining the consistency and the fairness of across the global maritime operations.

Lastly, the research paper recognizes the need for research in areas such as the ethical complications of autonomous navigation, the rising cybersecurity risks, and the development of comprehensive evidence-gathering protocols for autonomous incidents and the efforts included will be very crucial to building robust legal rules for the effective functioning of the maritime operations.

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