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## Legal Accountability of Deck Officers in Maritime Autonomous Surface Ships: A Normative Analysis of COLREGS and STCW Compliance Gaps in Indonesian Domestic Shipping

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**Abstract:** The rapid advancement of Maritime Autonomous Surface Ship (MASS) technology has exposed fundamental normative deficiencies in existing international maritime law, particularly in frameworks governing collision regulations and seafarer certification. This study examines legal accountability in MASS operations, where the traditional human–vessel nexus in COLREGS and STCW is disrupted. Using normative legal and comparative analysis, the study evaluates the adequacy of COLREGS 1972, STCW, SOLAS, and Indonesian Law No. 17 of 2008 in addressing accountability in MASS incidents. Through document analysis of IMO regulatory scoping exercise outputs, EU maritime law developments, and Indonesian domestic shipping regulations, supplemented by thematic expert consultations, the study identifies three principal normative gaps: the absence of a defined legal subject for autonomous decision-making, the inadequacy of STCW competency standards for remote operations, and the fragmented liability regime between flag states, operators, and technology developers. The study proposes a layered normative accountability model tailored to the Indonesian domestic shipping context. Findings contribute to the development of a coherent legal architecture capable of governing the transitional phase of maritime autonomy and offer actionable recommendations for Indonesian maritime regulatory reform.

**Keywords:** maritime autonomous surface ships, legal accountability, COLREGS, STCW, Indonesian maritime law.

### INTRODUCTION

MASS represents a major technological shift that disrupts existing maritime law. Maritime law assumes a human operator is present and legally responsible navigating international or domestic waters. This presumption pervades the International Regulations for Preventing Collisions at Sea (COLREGS 1972), the Standards of Training, Certification and Watchkeeping for Seafarers (STCW Convention), and the International Convention for the Safety of Life at Sea (SOLAS). Yet as autonomous and remotely operated vessels move from

experimental trials to commercial deployment — with companies such as Kongsberg Maritime, Rolls-Royce Marine, and Wärtsilä demonstrating fully unmanned operations across both short-sea and deep-sea routes — the legal architecture that governs maritime accountability is confronting a profound normative vacuum (Ringbom, 2019; Kim et al., 2020).

The question of legal accountability in MASS operations is not merely technical or theoretical; it is urgent and practically consequential. When an autonomous vessel collides with another ship, grounds on a reef, or causes a pollution incident, the existing legal order demands the identification of a responsible party — typically the Master, who under international maritime law bears the primary duty of care and navigational responsibility. Yet in a MASS scenario, the Master may be located in a remote operations center thousands of miles from the vessel, or the vessel may be operating under algorithmic control with no real-time human oversight at all. Under such conditions, foundational legal concepts including fault, negligence, command authority, and watchkeeping duty become extraordinarily difficult to apply (Veal & Tsimplis, 2017; Chircop, 2018). The result is a structural tension between the operational realities of maritime autonomy and the normative framework designed for a pre-autonomous era.

Legal uncertainty increases due to multiple MASS stakeholders. Where conventional maritime liability typically triangulates among the shipowner, the flag state, and the Master, the introduction of autonomous systems introduces software developers, remote operators, system integrators, and artificial intelligence vendors as parties whose decisions may causally contribute to maritime incidents (Papachristou, 2020). COLREGS and STCW do not regulate remote operators or shore-based navigation. The International Maritime Organization (IMO) recognized this regulatory deficiency in its landmark Regulatory Scoping Exercise (RSE), completed in 2021, which catalogued over forty international instruments requiring revision or reinterpretation to accommodate MASS operations (IMO, 2021). However, the RSE produced diagnostic findings rather than normative solutions, and the pace of regulatory reform within the IMO has not kept pace with technological development.

The challenge is particularly acute in Indonesia, the world's largest archipelagic state and one of the most complex maritime jurisdictions globally. With over 17,000 islands, Indonesian domestic shipping constitutes an essential artery for national connectivity, logistics, and economic integration. Indonesian Law No. 17 of 2008 on Shipping (Undang-Undang Pelayaran) and its implementing regulations were formulated within a thoroughly conventional maritime framework that makes no provision for autonomous or remotely operated vessels (Cahyadi, 2020). As Indonesian shipping companies begin exploring technology-driven operational efficiencies — and as MASS vessels operated by foreign partners enter Indonesian waters under bilateral or multilateral arrangements — the absence of a coherent domestic legal response to MASS accountability represents a growing governance risk.

Previous scholarship on MASS legality has made important initial contributions. Ringbom (2019) and Veal and Tsimplis (2017) have examined MASS integration into general maritime law through the lens of European and international frameworks, while Røsæg (2019) has explored liability regimes under North Sea operational conditions. Chircop (2018) assessed the adequacy of existing instruments under IMO auspices, and Felski and Zwolak (2020) addressed the navigational safety dimensions of ocean-going autonomous vessels. However, this body of scholarship shares a significant limitation: it predominantly engages with MASS accountability through the lens of international maritime law as applied in developed maritime nations, with limited attention to developing-country contexts — and virtually no normative analysis of how Indonesia's domestic shipping legal framework intersects with, or diverges from, the emerging MASS accountability discourse.

The present study addresses this gap directly. It undertakes a normative legal analysis of the accountability framework applicable to deck officer roles in MASS operations, focusing on

three principal instruments — COLREGS, STCW, and SOLAS — and their interaction with Indonesian maritime law. The study pursues three interrelated objectives: first, to analyze the normative adequacy of existing international maritime legal frameworks in relation to MASS operations, with particular reference to the accountability of deck officers; second, to identify specific gaps in legal accountability attribution among ship operators, software developers, flag states, and remote operators in the Indonesian context; and third, to propose a normative model for layered legal responsibility applicable to Indonesian domestic MASS shipping. The central research question animating the study is: *In the absence of explicit regulatory provisions for MASS, how should legal accountability for maritime incidents involving autonomous or semi-autonomous vessels be allocated under Indonesian maritime law and international maritime instruments?*

The rationale for this study is simultaneously theoretical, empirical, and institutional. Theoretically, the study contributes to the normative jurisprudence of maritime autonomy by extending accountability analysis to a jurisdictionally underrepresented context. Empirically, it provides actionable documentation of current legal gaps that have real-world implications for maritime safety governance in Indonesian waters. Institutionally, the study responds directly to the Indonesian Ministry of Transportation's emerging need for a regulatory framework capable of accommodating MASS developments consistent with Indonesia's national maritime policy (Poros Maritim Dunia) and international obligations under UNCLOS, SOLAS, and STCW. At a time when the IMO is actively developing a MASS Code and when regional maritime neighbors such as Singapore and Japan have already initiated domestic MASS regulatory frameworks, Indonesia's normative position on autonomous ship accountability demands rigorous scholarly examination. This study seeks to provide that examination.

## **Literature Review and Theoretical Framework**

### **Key Concepts: MASS, Legal Accountability, and the Human Element**

Understanding the legal implications of MASS requires, as a preliminary matter, a clear conceptualization of what autonomous maritime operation entails and how it reconfigures the foundational legal relationships of maritime law. The IMO has adopted a working definition of MASS as vessels that, to a varying degree, can operate independently of human interaction (IMO, 2021). This definition encompasses a spectrum of four operational degrees: ships with automated processes and decision support, remotely controlled ships with seafarers on board, remotely controlled ships without seafarers on board, and fully autonomous ships capable of making decisions independently. This tiered conception is significant because legal accountability cannot be assessed uniformly across all MASS degrees — the normative analysis must be sensitive to the specific degree of human disengagement involved in a given operation or incident.

Legal accountability, as it functions within maritime law, is anchored in the twin concepts of duty of care and command authority. Under both common law and civil law traditions as applied to maritime matters, the Master bears ultimate navigational responsibility for the safety of the vessel, its crew, and any third parties that may be affected by its navigation. This responsibility is codified in COLREGS through provisions requiring vessels to maintain a proper lookout (Rule 5), to proceed at a safe speed (Rule 6), and to take all necessary action to avoid collision (Rule 8). Critically, Rule 2 of COLREGS explicitly preserves the Master's overriding discretion to deviate from the rules in cases of special circumstances — a provision that presupposes human situational awareness and decision-making capacity (Papachristou, 2020; Carey & Knapp, 2019). In a fully autonomous system, it is deeply uncertain whether an algorithmic decision-making process satisfies the normative expectation embedded in these

provisions, or who bears responsibility when algorithmic navigation produces a harmful outcome.

The concept of the "human element" — extensively discussed in IMO instruments and the academic literature — has long been recognized as the primary causal factor in maritime accidents (Porathe, 2019; Burmeister et al., 2014). Paradoxically, MASS advocates contend that removing human fallibility from onboard navigation will improve safety outcomes. However, the displacement of the human element does not eliminate accountability; it displaces and fragments it across a new set of actors whose legal status within maritime law remains undefined. The theoretical challenge, therefore, is not whether accountability exists in MASS scenarios, but how existing legal frameworks must be interpreted or reformed to attribute it coherently.

### **Theoretical Framework: Normative Legal Theory and Regulatory Gap Analysis**

The study adopts a normative legal theory approach, informed by Hart's (1994) concept of the rule of recognition and the broader jurisprudential tradition of analytical positivism, which holds that the validity and application of legal rules must be assessed through their internal structure, their relationship to other norms in a legal system, and their capacity to regulate new phenomena arising after their enactment. This theoretical lens is appropriate for MASS accountability analysis because the central question is not whether maritime autonomy is socially desirable, but whether the existing corpus of maritime law as written and interpreted contains sufficient normative resources to govern MASS incidents — and if not, what form a normative response should take.

Complementing normative legal theory, the study draws on Regulatory Gap Theory as articulated by Black (2001) and more recently applied to maritime technology governance by Ringbom (2019). Regulatory gaps may be conceptual (the relevant concept — such as "Master" — does not apply to a new phenomenon), functional (the law applies in principle but lacks enforcement mechanisms), or structural (the jurisdictional boundaries of the law are ill-suited to the cross-border character of the regulated activity). All three gap types are present in the MASS accountability problem, and each requires a distinct normative remedy.

### **COLREGS and the Autonomous Navigation Problem**

A critical examination of COLREGS reveals that its provisions are fundamentally premised on vessel operation by a human crew capable of observation, judgment, and action. Rule 5 requires "all available means" to maintain a proper lookout "by sight and hearing as well as by all other available means" — language that implies embodied sensory capacity rather than algorithmic sensor fusion (Veal & Tsimplis, 2017). Rule 8, governing action to avoid collision, requires action to be "taken in ample time" and to be "large enough to be readily apparent to another vessel" — formulations that assume communicative intentionality between human navigators. Rule 17, governing the conduct of the stand-on vessel, requires the stand-on vessel to "take such action as will best aid to avoid collision" when it becomes apparent that the give-way vessel alone cannot avoid collision — a judgment-laden provision that may be difficult for autonomous systems to satisfy in legally cognizable terms.

Prior scholarly analyses have noted that COLREGS could theoretically accommodate MASS through expansive interpretation of existing provisions (Chircop, 2018). However, this interpretive approach is widely regarded as inadequate because it leaves critical accountability questions — particularly regarding fault attribution — unanswered (Papachristou, 2020). The IMO's RSE confirmed that COLREGS is among the instruments most urgently requiring amendment, yet concrete amendment proposals remain under development (IMO, 2021).

### **STCW and the Certification Gap for Remote Operations**

The STCW Convention, as amended by the 2010 Manila Amendments, establishes minimum standards for the training, certification, and watchkeeping of seafarers. Its provisions are structured around the assumption that certified officers are physically present on board the vessel they are navigating. The concept of Officer of the Watch (OOW), the Bridge Resource Management (BRM) standards, and the hours-of-rest requirements for watchkeeping personnel all presuppose an onboard operational environment (Kim et al., 2020). In a remotely controlled MASS scenario, the individual performing navigational functions may be seated at a shore-based control center, managing multiple vessels simultaneously, and operating in an entirely different regulatory jurisdiction from the vessel itself.

Scholarship by Burmeister et al. (2014) and Porathe (2019) has demonstrated that remote navigation introduces distinct cognitive demands, human-machine interaction challenges, and situational awareness deficiencies that differ substantially from conventional shipboard operations. These differences have not been incorporated into any existing STCW framework. The Manila Amendments make no provision for remote watchkeeping certification, and the competency standards for OOWs make no reference to shore-based control system proficiency. This regulatory omission is significant not only for safety reasons, but for legal accountability: if no STCW certification standard exists for remote operators, then their legal status as qualified watchkeepers — and therefore the legal basis for attributing navigational fault to them — remains entirely unresolved.

### **Liability Frameworks and the Multi-Actor Problem**

The classical maritime liability framework, as articulated in instruments such as the Limitation of Liability for Maritime Claims (LLMC) Convention and in domestic shipping laws, distributes legal responsibility among a relatively contained set of actors: the shipowner, the bareboat charterer where applicable, the Classification Society, and the Master. The introduction of MASS disrupts this framework by adding software developers and AI system providers as parties whose design choices may causally contribute to incidents (De la Rue & Anderson, 2020; Tetley, 2002). Product liability law — which would govern claims against software developers in many domestic legal systems — is poorly adapted to maritime contexts, which have their own specialized liability regimes developed over centuries of commercial practice.

Felski and Zwolak (2020) and Ringbom (2019) have independently argued that the multi-actor character of MASS liability requires a specifically designed normative instrument — likely in the form of a new IMO convention or protocol — rather than fragmented adaptation of existing instruments. Røsæg (2019) has proposed that a functional equivalence approach, interpreting MASS operator responsibilities as analogous to Master responsibilities where operationally justified, could bridge the gap pending formal regulatory reform. While functionally pragmatic, this approach lacks the normative clarity required for consistent judicial application, particularly in developing-country jurisdictions where maritime case law is less developed.

### **The Indonesian Legal Context and Identified Research Gap**

Within the Indonesian context, Law No. 17 of 2008 on Shipping provides the primary domestic legal framework governing maritime operations, safety, and accountability. The law establishes detailed provisions regarding the responsibilities of the Nakhoda (Master), the duties of shipping companies, and the oversight functions of the Directorate General of Sea Transportation (Ditjen Hubla). However, the law contains no provisions addressing autonomous or remotely operated vessels, makes no reference to software or algorithmic navigation systems, and contains no framework for attributing accountability to shore-based

operators (Cahyadi, 2020; Priyatna, 2019). The absence of such provisions is not merely a legislative oversight — it reflects the fact that MASS technology was not operationally significant when the law was drafted. However, as Indonesian shipping companies, the national coast guard, and maritime education institutions such as STIP Jakarta begin engaging with MASS-related technology, the normative gap becomes increasingly urgent.

The present study is situated precisely at this intersection: between the internationally recognized normative inadequacy of COLREGS and STCW for MASS governance, and the specific domestic legal vacuum in Indonesian maritime law. No prior study has undertaken a systematic normative analysis of MASS accountability that integrates IMO instruments, comparative international maritime law, and Indonesian domestic shipping law into a coherent analytical framework. This constitutes the principal gap this research addresses.

## **METHOD**

This study employs normative legal research as its primary methodological framework, supplemented by comparative law analysis and expert consultation. Normative legal research, as a formal jurisprudential methodology, examines the internal coherence, adequacy, and application of legal rules and principles to a defined problem — in this case, the attribution of accountability in MASS-related maritime incidents (Marzuki, 2017). This methodology is appropriate because the study's central objective is not to measure empirical outcomes but to evaluate the normative structure of existing legal instruments and to propose a coherent accountability model.

The primary data sources consist of international maritime legal instruments — COLREGS 1972, STCW 1978 as amended in 2010, SOLAS 1974, and the IMO's Regulatory Scoping Exercise Output (MSC-LEG-MEPC.2/Circ.3, 2021) — alongside Indonesian domestic maritime law, principally Law No. 17 of 2008 and its implementing regulations. Secondary sources include EU maritime law instruments and national MASS regulatory frameworks from comparative jurisdictions, including the Netherlands, Norway, and Singapore, selected for their advanced positions in MASS governance and their methodological relevance to Indonesian regulatory reform. Document selection followed a purposive logic guided by the research objectives: only instruments with direct normative relevance to accountability attribution in MASS contexts were included (Creswell & Poth, 2018).

Expert consultation data were collected through semi-structured interviews with eight participants, comprising three maritime law academics, two senior officers from the Directorate General of Sea Transportation (Ditjen Hubla), two maritime technology specialists, and one representative from a classification society with MASS operational experience. Participants were selected using theoretical sampling to ensure that the full range of relevant normative perspectives — legal, regulatory, and technical — was represented (Braun & Clarke, 2006). Interviews were conducted in Indonesian and English, recorded with participant consent, and transcribed verbatim for analysis.

Data analysis proceeded through three integrated procedures. First, Thematic Analysis was applied to the legal documents and interview transcripts, identifying recurring normative categories and accountability constructs across the data corpus. Second, Cross-group Comparison was conducted to identify convergences and divergences in the interpretive positions of legal scholars, regulatory officials, and technical specialists. Third, Narrative Synthesis was used to integrate the documentary and interview findings into a coherent normative account that could support the development of the proposed accountability model (Popay et al., 2006). Throughout the analysis, reflexivity was maintained by triangulating findings across documentary and interview sources, ensuring that the normative conclusions were grounded in multiple evidentiary bases rather than in single-source interpretation.

## RESULTS AND DISCUSSION

### Overview of Findings

The analysis produced findings organized around three principal normative dimensions: (a) the adequacy of COLREGS for MASS navigational accountability, (b) the adequacy of STCW for remote operator certification, and (c) the attribution of liability in multi-actor MASS incidents under Indonesian maritime law. These dimensions correspond directly to the study's three research objectives and to the thematic categories that emerged from the document analysis and expert consultations. Findings are presented below in structured thematic form, supported by tabular and visual data displays.

### Theme 1: COLREGS Adequacy for MASS Navigational Accountability

The document analysis of COLREGS provisions revealed five rules whose application to MASS operations is critically uncertain: Rule 2 (responsibility), Rule 5 (lookout), Rule 6 (safe speed), Rule 8 (action to avoid collision), and Rule 17 (action by stand-on vessel). Expert respondents unanimously assessed all five provisions as requiring either amendment or authoritative reinterpretation to accommodate MASS operations. Table 1 presents a structured normative adequacy assessment of these provisions.

**Table 1. Normative Adequacy Assessment of Key COLREGS Provisions for MASS Operations**

COLREGS Rule	Core Requirement	Human-Centric Assumption	MASS Adequacy Assessment	Expert Consensus
<b>Rule 2 – Responsibility</b>	Master's overriding discretion	Embodied human judgment	Inadequate – no legal subject for algorithmic discretion	Not adequate
<b>Rule 5 – Lookout</b>	Sight, hearing, all available means	Sensory human presence	Partially applicable via sensor fusion, but legally uncertain	Partially adequate
<b>Rule 6 – Safe Speed</b>	Consider all relevant factors	Human situational awareness	Technically adaptable, normatively unclear accountability	Partially adequate
<b>Rule 8 – Collision Avoidance</b>	Ample time, bold action	Navigational judgment and communication	Not adequate – algorithmic action lacks legal intentionality	Not adequate
<b>Rule 17 – Stand-on Vessel</b>	Take best action when give-way fails	Real-time human situation assessment	Not adequate – autonomous response lacks legal duty attribution	Not adequate

The pattern emerging from Table 1 is clear: provisions requiring the exercise of active human judgment — Rules 2, 8, and 17 — are normatively inadequate for MASS contexts, while provisions amenable to technological substitution — Rules 5 and 6 — are only partially adequate due to unresolved accountability attribution. Particularly significant is the inadequacy of Rule 2, which is the ultimate accountability anchor of COLREGS: without a legally recognized subject capable of exercising overriding discretion, the entire normative hierarchy of COLREGS loses its grounding.

Expert respondents reinforced this finding, with all eight interviewees identifying Rule 2 as the most fundamental normative obstacle to MASS accountability under COLREGS. One maritime law academic observed that COLREGS fundamentally assumes a human decision-maker at the apex of navigational authority, and that no interpretive expansion of existing provisions can substitute for the creation of a new legal subject — whether a remote operator, a system operator, or a designated legal person — to occupy that apex.

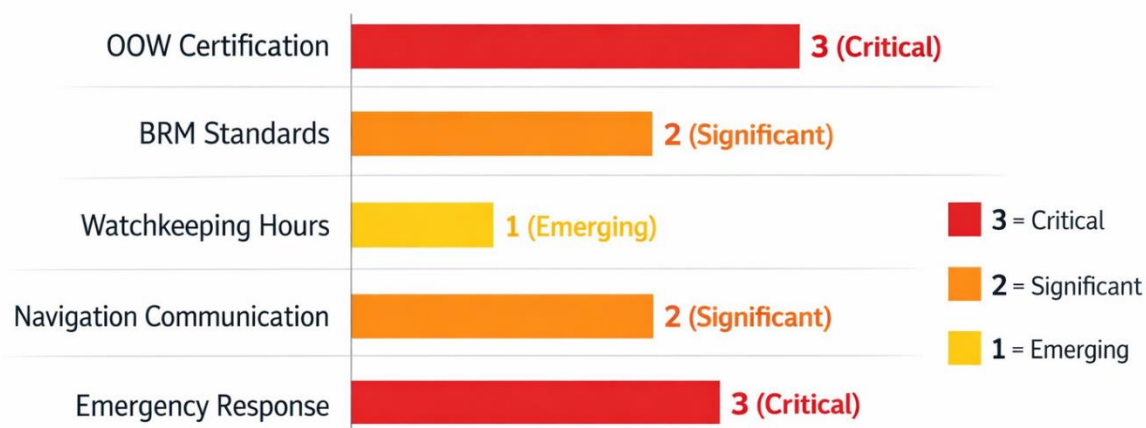
### Theme 2: STCW Certification Gaps for Remote Operators

Analysis of STCW provisions against the functional requirements of MASS remote operation identified four principal certification gaps: (1) the absence of a recognized competency framework for shore-based navigational control; (2) the non-applicability of existing OOW certification to multi-vessel remote management; (3) the inadequacy of BRM standards for remote human-machine interface (HMI) environments; and (4) the absence of watchkeeping hour provisions applicable to shore-based operators.

**Table 2. STCW Certification Framework vs. MASS Remote Operation Requirements**

STCW Requirement	Current Standard	MASS Remote Operation Requirement	Normative Gap Status
<b>Officer of the Watch (OOW) Certification</b>	STCW A-II/1 – onboard vessel	Shore-based control center operation	Critical gap – no equivalent standard
<b>Bridge Resource Management (BRM)</b>	Onboard team dynamics, SOLAS Ch. V	Remote HMI, multi-vessel coordination	Significant gap – BRM not designed for remote settings
<b>Watchkeeping Hours of Rest</b>	STCW A-VIII/1 – minimum rest periods	Shore-based operator cognitive load management	Partial gap – principle applicable but standard undefined
<b>Navigation Communication Competency</b>	GMDSS, onboard radio procedures	Remote communication protocols, cybersecurity	Emerging gap – GMDSS not designed for remote ops
<b>Emergency Response Competency</b>	Onboard emergency procedures	Remote emergency override capability	Critical gap – remote emergency authority undefined

Figure 1 illustrates the relative severity of certification gaps across the five STCW competency dimensions identified in Table 2, based on expert assessment using a three-level severity scale (critical, significant, emerging).



**Figure 1. Expert-Assessed Severity of STCW Certification Gaps for MASS Remote Operations**

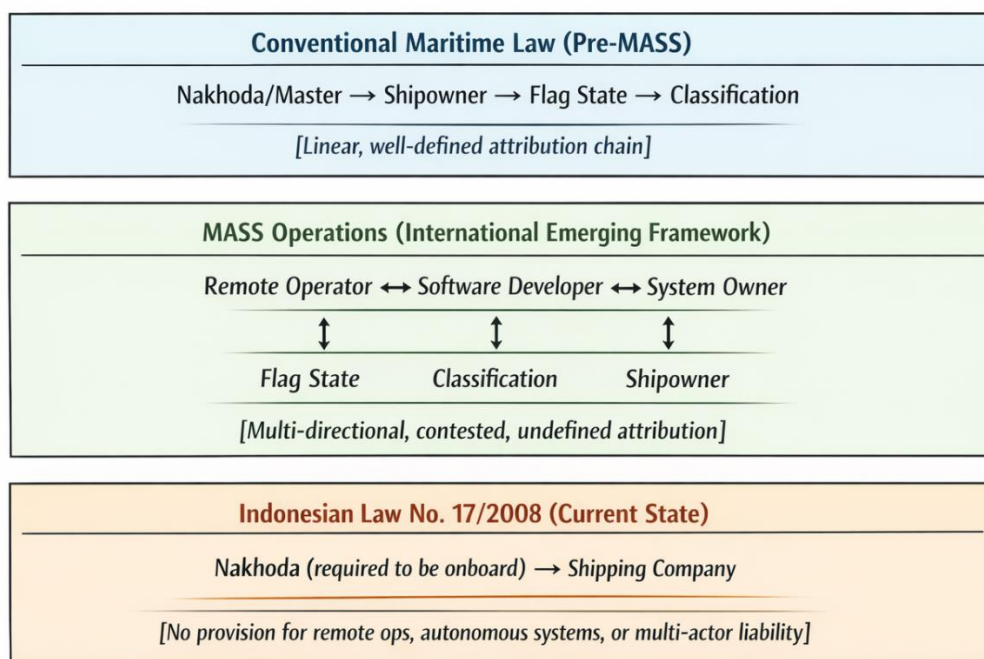
Expert respondents from Ditjen Hubla emphasized that the absence of an STCW-equivalent certification for remote operators creates not only a safety governance problem but a direct legal accountability problem: without certification, it is impossible to establish the standard of care against which remote operator conduct can be evaluated in post-incident proceedings.

### Theme 3: Liability Attribution in Indonesian Maritime Law

Cross-group comparison of expert perspectives on Indonesian maritime law produced significant divergence between legal scholars and regulatory officials regarding the interpretive resources available within Law No. 17 of 2008. Legal scholars unanimously assessed the law as inadequate to govern MASS accountability, noting that its provisions on the Nakhoda's responsibilities (Articles 138–152) are framed exclusively in terms of physical presence aboard the vessel. Regulatory officials, by contrast, suggested that certain provisions — particularly those governing shipping companies' obligations and flag state oversight — could be interpreted to impose accountability on operators of autonomous vessels, though they acknowledged this interpretation had not been tested in any Indonesian maritime case.

The most significant finding in the Indonesian legal analysis concerns the structure of liability attribution. Under Law No. 17 of 2008, liability flows from the individual Nakhoda to the shipping company (Articles 239–245). In a MASS scenario, the Nakhoda role is either absent (fully autonomous) or fundamentally transformed (remote operator). Neither Law No. 17 of 2008 nor any existing implementing regulation provides a mechanism for attributing liability to a shore-based operator, a software developer, or a system integrator. Furthermore, there is no Indonesian legal instrument regulating the domestic use of AI or algorithmic decision-making in safety-critical transportation contexts, creating a cross-domain normative gap between maritime law and technology law.

Figure 2 presents a comparative analysis of the liability attribution architecture across three frameworks: conventional maritime law, existing MASS-relevant international instruments, and Indonesian Law No. 17 of 2008.



**Figure 2. Comparative Liability Attribution Frameworks**

The comparative visual makes apparent that the accountability architecture of Indonesian maritime law is not merely incomplete in relation to MASS operations — it is structurally incompatible with the multi-actor liability reality that MASS creates. The linear attribution model of Law No. 17 of 2008 has no normative mechanism to accommodate the distributed causal responsibility that characterizes autonomous vessel incidents.

## Discussion

### Reconnecting Findings to Research Objectives

The findings presented in the preceding section provide a coherent and multi-layered response to the study's central research question regarding the allocation of legal accountability for maritime incidents involving autonomous or semi-autonomous vessels under Indonesian maritime law and international maritime instruments. The analysis confirms, with specificity and evidence, that the current normative frameworks are inadequate across all three dimensions examined: COLREGS navigational accountability, STCW operator certification, and Indonesian domestic liability law. This inadequacy is not incidental — it is structural, arising from the foundational design logic of all three frameworks, which presupposes human physical presence and embodied judgment in vessel operations.

The most consequential finding concerns Rule 2 of COLREGS. This provision functions as the normative keystone of the collision prevention regime: it establishes that nothing in COLREGS exonerates a vessel for failing to take action required by the ordinary practice of seamanship, and it preserves the Master's overriding discretion. In legal terms, Rule 2 creates a residual duty of care that catches situations the specific rules do not address. In a MASS context, where no human Master is present aboard the vessel, this residual accountability anchor is removed. The algorithmic system that replaces the Master's judgment cannot bear legal responsibility, and no existing norm unambiguously transfers this responsibility to the remote operator, the system developer, or the flag state. This is not merely an interpretive gap — it is a lacuna in the positive law that no amount of creative judicial interpretation can satisfactorily fill without legislative action.

### Theoretical Implications: Regulatory Gap Theory Applied

The findings provide empirical substantiation for Regulatory Gap Theory as applied to maritime technology governance. Black's (2001) tripartite taxonomy of regulatory gaps — conceptual, functional, and structural — is borne out by the analysis. The conceptual gap is most visible in STCW: the concept of "Officer of the Watch" presupposes physical presence aboard the vessel, and no amount of interpretive extension can map it onto the reality of a shore-based operator managing multiple autonomous vessels simultaneously. The functional gap is most evident in Indonesian law: while certain provisions of Law No. 17 of 2008 could theoretically be applied to MASS operators, the enforcement mechanisms and institutional competencies required to operationalize such application do not exist. The structural gap is most acute in relation to COLREGS: as an international instrument applied through domestic enforcement, COLREGS faces jurisdictional complexity when MASS vessels operate across multiple flag state jurisdictions simultaneously.

Ringbom's (2019) argument that MASS governance requires a specifically designed normative instrument — rather than fragmented adaptation of existing ones — is strongly supported by these findings. The functional equivalence approach advocated by Røsæg (2019), while pragmatically valuable in the interim period, does not resolve the structural incompatibility between the linear accountability model of existing maritime law and the distributed causality of MASS operations. The present study extends these theoretical positions by specifying the precise normative architecture required in the Indonesian domestic context, thereby contributing to the development of a context-sensitive MASS accountability framework rather than a generic international model.

### The Proposed Normative Accountability Model

Drawing on the thematic findings and comparative legal analysis, the study proposes a Layered Normative Accountability Model (LNAM) for MASS operations in Indonesian domestic shipping. The model operates through three concentric layers of accountability. The

primary accountability layer assigns responsibility to the Designated Remote Operator (DRO), a newly created legal subject who bears STCW-equivalent certification for shore-based navigation and who stands in the same legal position as the onboard Master for accountability purposes. This layer responds directly to the conceptual gap in current law by creating a defined legal subject for autonomous decision-making. The secondary accountability layer assigns residual responsibility to the System Operator (typically the shipowner or operator company) for incidents where the DRO cannot be identified, where the autonomous system overrides remote operator control, or where system malfunction — rather than human error — is the proximate cause of the incident. The tertiary accountability layer assigns regulatory oversight responsibility to the Indonesian flag state authority (Ditjen Hubla) for verifying DRO certification, system safety standards, and operational compliance, with corresponding liability exposure where oversight failures contribute to incidents.

This layered model aligns with the internationally emerging functional equivalence principle while providing the normative clarity required for domestic judicial application. It is consistent with Indonesian administrative law traditions, which favor tiered regulatory structures for complex technical governance, and it provides a feasible implementation pathway within the existing framework of Law No. 17 of 2008 through ministerial regulation pending formal legislative amendment.

### **Engagement with Prior Literature**

The findings of this study are broadly consistent with the international scholarship on MASS legal inadequacy (Veal & Tsimplis, 2017; Chircop, 2018; Papachristou, 2020) while extending that scholarship in important contextual and normative directions. Unlike prior studies, which have analyzed MASS accountability primarily through the lens of developed maritime nations with sophisticated domestic maritime judiciary systems, this study demonstrates that the accountability problem is qualitatively different — and in some respects more acute — in developing-country contexts where maritime case law is sparse, regulatory enforcement capacity is limited, and domestic legal instruments have not been updated to reflect MASS-era developments. The finding that Indonesian Law No. 17 of 2008 is structurally incompatible with MASS accountability — rather than merely incomplete — advances the normative analysis beyond what prior international studies have established.

The study's engagement with STCW certification gaps for remote operators complements the work of Burmeister et al. (2014) and Porathe (2019) on human factors in remote navigation by providing the legal accountability dimension of the certification problem. The lack of an STCW framework for remote operators is not merely a safety training issue — it is a fundamental obstacle to legal accountability because it removes the standard of care reference point against which remote operator conduct can be evaluated.

### **Strengths, Limitations, and Future Research**

The principal strength of this study lies in its methodological integration of normative legal analysis, comparative law, and expert consultation, which produces a multi-layered and triangulated assessment of the accountability problem. The comparative dimension — engaging Indonesian law alongside international instruments and comparator jurisdiction frameworks — adds contextual depth that purely international analyses lack.

Several limitations must be acknowledged. The expert consultation sample, while theoretically representative, was limited in size and did not include representatives from private shipping companies or maritime technology vendors — perspectives that could have enriched the analysis of the secondary and tertiary accountability layers. Additionally, the rapidly evolving character of IMO MASS regulatory development means that some normative findings may require revision as the MASS Code progresses toward adoption. Future research should

examine the implementation of the proposed LNAM through regulatory pilot programs in Indonesian domestic shipping routes, assess the feasibility of STCW amendment through Indonesia's participation in IMO working groups, and investigate the intersection of MASS accountability with Indonesia's emerging cybersecurity law framework, which is likely to become increasingly relevant as autonomous navigation systems become targets for cyber incidents.

## CONCLUSION

This study has demonstrated that the legal accountability frameworks governing deck officer responsibilities — principally COLREGS, STCW, and Indonesian Law No. 17 of 2008 — are structurally inadequate to govern maritime incidents involving autonomous or semi-autonomous vessels. The analysis identified critical normative gaps across three dimensions: the absence of a legally recognized subject for autonomous navigational decision-making under COLREGS, the non-existence of STCW certification standards for shore-based remote operators, and the structural incompatibility of Indonesia's domestic maritime liability framework with multi-actor MASS accountability. In response, the study proposed a Layered Normative Accountability Model that assigns tiered responsibility to a Designated Remote Operator, the system operating company, and the Indonesian flag state authority. This model offers a practically implementable and theoretically coherent framework for Indonesian maritime regulatory reform, contributing both to domestic shipping governance and to the growing international scholarship on MASS legal accountability.

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