

Regulatory Redundancy in Modern Maritime Navigation Equipment: A Critical Analysis of Course Recorders, Echo Sounders and Voyage Data Recorders

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Abstract: This paper examines the regulatory gap concerning redundant navigation equipment on modern commercial vessels, specifically analyzing the functional overlap between traditional course recorders, echo sounders, and Voyage Data Recorders (VDRs). Through a systematic review of International Maritime Organization (IMO) regulations, classification society guidance, flag state interpretations, and industry association publications, this research reveals a comprehensive absence of official guidance harmonizing SOLAS Chapter V Regulations 19 and 20. The findings demonstrate that VDRs record all parameters captured by standalone course recorders and echo sounders, yet shipowners continue to bear the operational costs of maintaining redundant equipment due to regulatory ambiguity. This paper argues that the regulatory framework has not adapted to technological advancement, creating unnecessary economic burden on the maritime industry while maintaining the appearance of compliance with outdated operational assumptions. The analysis concludes with recommendations for regulatory modernization and calls for IMO action to address this systematic inefficiency.

Keywords: Maritime Navigation, SOLAS Regulations, Voyage Data Recorder, Course Recorder, Equipment Redundancy, Regulatory Modernization, IMO Policy, Echo Sounder.

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I. INTRODUCTION

The International Convention for the Safety of Life at Sea (SOLAS) establishes comprehensive equipment requirements for commercial vessels, including multiple systems for recording and displaying navigational parameters. Since the mandatory implementation of Voyage Data Recorders (VDRs) beginning in 2002, modern ships carry sophisticated recording systems that capture comprehensive bridge data for accident investigation and operational analysis. However, SOLAS Chapter V also maintains separate requirements for traditional navigation equipment, including course recorders (heading recording devices) and echo sounders, creating potential functional redundancy.

This research investigates whether regulatory requirements have kept pace with technological advancement, or whether maritime regulations perpetuate equipment redundancy based on outdated operational assumptions. The central research question examines: Do VDRs functionally supersede standalone course recorders

and echo sounders, and if so, why does the regulatory framework continue to require both systems?

This question has significant economic implications for shipowners, who bear the operational costs of installing, maintaining, calibrating, and powering equipment that may serve primarily forensic rather than operational purposes.

➤ Research Objectives

This paper seeks to:

- Document the functional capabilities of VDRs in recording navigational parameters currently captured by standalone equipment.
- Systematically review regulatory guidance from IMO, classification societies, flag states, and industry associations regarding equipment redundancy.
- Analyze the evidentiary hierarchy between VDR data and course recorder data in maritime legal contexts.
- Examine whether echo sounders retain operational value distinct from VDR recording capabilities.

- Propose regulatory recommendations to address identified gaps and inconsistencies.

➤ *Significance*

This research addresses a critical gap in maritime policy literature. Despite the widespread adoption of VDRs over two decades, no academic studies have systematically examined the regulatory redundancy created by overlapping SOLAS requirements. This analysis provides empirical documentation of regulatory inertia and offers a framework for modernizing maritime equipment regulations to reflect current technological capabilities.

II. LITERATURE REVIEW AND REGULATORY FRAMEWORK

➤ *Voyage Data Recorders: Regulatory History and Technical Capabilities*

Following major maritime casualties including the Estonia disaster (1994) and the investigation challenges posed by inadequate data preservation, the International Maritime Organization adopted mandatory VDR requirements through amendments to SOLAS Chapter V.

- *Regulation 20 Requires VDRs on:*
- Passenger ships constructed on or after 1 July 2002.
- Ro-ro passenger ships constructed before 1 July 2002, by 1 July 2002.
- Ships other than passenger ships of 3,000 gross tonnage and upwards, constructed on or after 1 July 2002.

VDRs record a minimum of 12 hours of data across multiple parameters, including: date and time, ship position (latitude and longitude), speed, heading, bridge audio conversations, VHF radio communications, radar display information, echo sounder (depth under keel), main alarms, rudder order and response, engine order and response, hull openings status, watertight and fire door status, accelerations and hull stresses, and wind speed and direction.

- *Simplified Voyage Data Recorders (S-VDRs)*

For certain existing ships constructed before 1 July 2002, SOLAS permits the installation of Simplified Voyage Data Recorders (S-VDRs) as an alternative to full VDRs. S-VDRs were designed to address the practical difficulties of retrofitting comprehensive VDR systems to older vessels with analog sensors and non-standard interfaces. S-VDRs record a reduced set of mandatory parameters compared to full VDRs. Critically, S-VDRs are not required to record several parameters that are mandatory for full VDRs. Additionally, echo sounder data is only recorded by S-VDRs if standard interfaces are available on the vessel.

This distinction has important implications for the equipment redundancy analysis. While S-VDRs mandatorily record heading data (creating the same redundancy with course recorders as full VDRs), they may not record echo sounder data on all vessels. On ships equipped with S-VDRs where echo sounder interfaces are unavailable, standalone

echo sounders retain both operational and forensic recording functions, presenting a different redundancy profile than vessels with full VDRs.

➤ *Traditional Navigation Equipment Requirements*

SOLAS Chapter V Regulation 19 establishes separate requirements for navigational systems and equipment.

- *Relevant Provisions Include:*

- ✓ Regulation 19.2.3.5 (applicable to ships 300 GT and upwards): requires “a properly adjusted transmitting heading device, or other means, to transmit heading information for input to the equipment referred to in paragraphs 2.3.2, 2.3.3 and 2.4.”
- ✓ Regulation 19.2.3.1 (applicable to ships 300 GT and upwards): mandates “an echo-sounding device, or other electronic means, to measure and display the available depth of water.”
- ✓ Regulation 19.2.5.1 (applicable to ships 500 GT and upwards): requires “a gyro compass, or other means, to determine and display their heading by shipborne non-magnetic means... These means shall also transmit heading information for input to the equipment referred in paragraphs 2.3.2, 2.4 and 2.5.5.”

These requirements historically necessitated standalone course recorders (to document heading over time) and echo sounders (to display and record depth). However, the regulatory text uses the phrase “or other means,” creating potential flexibility for technological alternatives.

➤ *Functional Overlap Analysis*

Course recorders serve a singular function: receiving heading data from the ship’s master gyrocompass and creating a continuous graphical plot of the ship’s heading against a time scale. VDRs record heading as one of their mandatory parameters, capturing the same information with superior temporal resolution, tamper-resistance, and integration with other bridge data. Similarly, VDRs record echo sounder data showing depth under keel, duplicating the data preservation purpose of standalone echo sounders, though echo sounders additionally provide real-time operational display and alarm functions.

III. METHODOLOGY

This research employed a systematic documentary analysis approach, examining official guidance and regulatory interpretations from multiple authoritative sources within the maritime regulatory ecosystem.

➤ *Search Strategy*

Comprehensive searches were conducted across the following domains:

- International Maritime Organization circulars, resolutions, and interpretations.

- Classification society rules and guidance notes (Lloyd’s Register, DNV, American Bureau of Shipping, Bureau Veritas).
- Flag state administrations (United Kingdom Maritime and Coastguard Agency, United States Coast Guard, Liberia, Marshall Islands, Panama, Singapore).
- Industry associations (BIMCO, International Chamber of Shipping). - Protection and Indemnity Clubs (International Group of P&I Clubs member publications).
- Academic maritime journals (Marine Policy, Maritime Policy & Management, Journal of Marine Science and Engineering, Maritime Transport Research).

Search terms included variations of: VDR, voyage data recorder, course recorder, heading recording device, echo sounder, SOLAS V/19, SOLAS V/20, equipment redundancy, navigation equipment, and regulatory interpretation.

➤ *Inclusion Criteria*

Documents were included if they: provided official regulatory guidance on SOLAS Chapter V navigation equipment; addressed the relationship between VDR requirements and traditional navigation equipment; discussed equipment redundancy in maritime operations; or examined regulatory harmonization issues in maritime safety equipment.

IV. FINDINGS

➤ *Absence of Official Guidance*

The research reveals a comprehensive absence of official regulatory guidance addressing the relationship between VDR requirements and traditional navigation equipment mandates. This gap exists across all examined regulatory authorities as summarized in Table 1.

Table 1 Absence of Official Guidance

Authority	Guidance Located	Status
International Maritime Organization	None	No interpretation or circular addressing equipment redundancy
Classification Societies (IACS)	None	No unified guidance from IACS or individual societies
Flag State Administrations	None	No interpretations from major flag states examined
BIMCO	None	No guidance notes or position papers
International Chamber of Shipping	None	No industry position on equipment rationalization
P&I Clubs	VDR guidance only	Focus exclusively on VDR data for claims; no mention of course recorders
Academic Literature	None	Zero journal articles addressing equipment redundancy

➤ *Course Recorder Redundancy*

Course recorders provide a single data stream: ship’s heading over time. VDRs record this identical parameter as part of their comprehensive data suite. The research identifies complete functional redundancy: - Both systems record heading from the same source (master gyrocompass). - VDR provides superior temporal resolution and data integrity. - VDR data is tamper-resistant and internationally standardized. - Course recorders add no unique operational or forensic value.

Despite this complete functional overlap, SOLAS V/19 and V/20 exist as separate, unharmonized regulations. No regulatory authority has issued guidance stating that VDR compliance satisfies the heading recording requirement of Regulation 19.2.3.5 or 19.2.5.1.

➤ *Echo Sounder Analysis*

Echo sounders present a more nuanced case. While full VDRs record depth under keel data (satisfying the recording function), echo sounders provide: real-time operational display of current depth; shallow water alarm functionality; and immediate feedback for navigation decisions.

However, operational practice raises questions about this distinction. With Electronic Chart Display and Information Systems (ECDIS) providing comprehensive depth information along planned routes, the operational

value of real-time echo sounder displays diminishes. ECDIS offers predictive depth information along the vessel’s track, safety contour and depth alarm functions, and integration with passage planning systems. The theoretical operational value of echo sounders assumes active monitoring and cross-checking by bridge personnel, a practice that may not reflect current operational realities on modern bridges.

• *S-VDR Distinction:*

The redundancy analysis for echo sounders must account for vessel type. Ships equipped with full VDRs experience complete functional redundancy in the recording function, as VDRs mandatorily capture depth data. However, vessels permitted to carry S-VDRs present a different scenario, creating a bifurcated regulatory situation where equipment redundancy exists on some vessels (full VDR) but not others (S-VDR without echo sounder interface).

➤ *Evidentiary Considerations*

From an evidentiary perspective under Indian law, both course recorder and VDR data would be admissible as electronic records under the Bharatiya Sakshya Adhiniyam, 2023. However, courts would likely assign greater weight to VDR data due to its comprehensiveness, tamper-resistance, international regulatory recognition, and superior chain of custody documentation.

The research found no case law where conflicting data from course recorders and VDRs required judicial determination. This absence itself suggests that in practice, VDR data has become the definitive source for forensic reconstruction of navigation events. Protection and Indemnity Clubs demonstrate this primacy through their exclusive focus on VDR data in claims guidance, indicating that for insurance and liability purposes, VDR data alone is considered sufficient and authoritative.

V. DISCUSSION

➤ *Regulatory Inertia and Technological Change*

The findings reveal a significant gap between technological capability and regulatory framework. VDR technology, now mature and widely implemented for over two decades, has effectively superseded the functional purpose of course recorders. Yet SOLAS Chapter V maintains these as separate, unharmonized requirements.

This regulatory inertia creates several consequences.

- *Economic Burden on Shipowners:*

Shipowners bear unnecessary costs for initial installation, ongoing maintenance, power consumption, and survey certification of redundant equipment.

- *Regulatory Ambiguity:*

The absence of official interpretation creates uncertainty, forcing shipowners to maintain both systems out of regulatory caution. This ambiguity is particularly striking given SOLAS V/19's use of the permissive phrase "or other means" and that industry practice treats VDR data as definitive.

- *Maintenance of Regulatory Fiction:*

The continued requirement perpetuates assumptions about bridge operations that may not reflect current practice, which is characterized by automation reliance and integrated systems.

➤ *Comparison to Historical Precedent: Radio Officers*

The maritime industry has previously experienced the elimination of specialized positions due to technological advancement. Radio officers were rendered obsolete by the Global Maritime Distress and Safety System (GMDSS) implementation in the 1990s. This precedent demonstrates that technological advancement can make specialized skills obsolete, regulations eventually adapt but with significant lag, and that skills once valued highly can be devalued by society's embrace of automation.

➤ *The Role of Economic Forces*

Economic pressure consistently drives maritime industry evolution. The persistence of equipment redundancy despite clear economic inefficiency suggests regulatory frameworks have not kept pace. While IMO processes emphasize safety and international consensus, economic efficiency receives less explicit consideration, creating situations where regulations impose costs without commensurate safety benefits. The question is not whether

economic forces will eventually drive change, but rather whether regulatory authorities will proactively address inefficiencies or wait for economic pressure to force reactive adjustments.

VI. RECOMMENDATIONS

Based on the research findings, this paper proposes the following regulatory actions:

➤ *IMO Action*

- Recommendation 1: The IMO Maritime Safety Committee should issue a circular clarifying that VDR compliance satisfies the heading recording requirements of SOLAS V/19.2.3.5 and 19.2.5.1 for vessels on which VDRs are mandatory.
- Recommendation 2: SOLAS Chapter V should be amended to harmonize Regulations 19 and 20, explicitly recognizing VDR data recording as satisfying traditional equipment requirements where functional overlap exists.
- Recommendation 3: IMO should establish a systematic review process for identifying and eliminating regulatory redundancies created by technological advancement.

➤ *Classification Society and Flag State Action*

- Recommendation 4: IACS should develop unified guidance on navigation equipment redundancy.
- Recommendation 5: Flag state administrations should issue interpretations acknowledging VDR compliance as satisfying heading recording requirements, pending IMO action.

➤ *Industry Association Engagement*

- Recommendation 6: BIMCO and ICS should formally petition IMO to address this regulatory gap.
- Recommendation 7: Industry associations should develop best practice guidance on bridge equipment rationalization.

➤ *Research Agenda*

- Recommendation 8: Maritime research institutions should conduct a comprehensive cost-benefit analysis of equipment redundancy.
- Recommendation 9: Operational studies should examine actual bridge practices regarding traditional navigation equipment use.

VII. LIMITATIONS

This research has several limitations that should be acknowledged: the study relied on publicly available documents; absence of guidance does not definitively prove no guidance exists, though comprehensive search methods minimize this risk; the analysis focused on regulatory documentation rather than empirical observation of actual

bridge practices; economic impact calculations were not quantified; and the paper does not address potential safety arguments for maintaining redundant equipment as backup systems.

VIII. CONCLUSION

This research has documented a significant regulatory gap in maritime navigation equipment requirements. Voyage Data Recorders, mandated on commercial vessels since 2002, record comprehensive bridge data including all parameters captured by traditional course recorders and echo sounders. Despite this functional redundancy, SOLAS Chapter V maintains separate, unharmonized requirements for these systems. Systematic review of regulatory authorities reveals a complete absence of official guidance addressing this overlap, forcing shipowners to maintain redundant systems at unnecessary cost.

The findings demonstrate clear functional redundancy for course recorders. Echo sounders present a more nuanced case, as they provide real-time operational display functions alongside data recording. However, with ECDIS offering predictive depth information and integrated alarms, the unique operational value of standalone echo sounders warrants examination. From an evidentiary perspective, VDR data would likely receive greater weight in legal proceedings. This situation reflects broader regulatory inertia in adapting to technological change. The paper recommends that IMO issue clarifying guidance and amend SOLAS Chapter V to harmonize Regulations 19 and 20. This research contributes to maritime policy literature by documenting a previously unexamined regulatory gap and providing an empirical foundation for regulatory modernization efforts.

➤ *Conflict of Interest*

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

➤ *Author Contributions*

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➤ *Data Availability Statement*

The original contributions presented in this study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

REFERENCES

- [1]. Baltic and International Maritime Council (BIMCO). (2024). About BIMCO. Retrieved from <https://www.bimco.org>
- [2]. Bharatiya Sakshya Adhiniyam. (2023). Act No. 47 of 2023. Government of India.
- [3]. International Chamber of Shipping. (2024). About ICS. Retrieved from <https://www.ics-shipping.org>
- [4]. International Maritime Organization. (2002). Resolution MSC.163(78): Performance Standards for Voyage Data Recorders (VDRs).
- [5]. International Maritime Organization. (2014). SOLAS Consolidated Edition 2014. Chapter V: Safety of Navigation, Regulation 19 - Carriage Requirements for Shipborne Navigational Systems and Equipment.
- [6]. International Maritime Organization. (2014). SOLAS Consolidated Edition 2014. Chapter V: Safety of Navigation, Regulation 20 - Voyage Data Recorders (VDRs).
- [7]. Liberian Registry. (2024). SOLAS Chapter V Regulation 19: Carriage Requirements for Shipborne Navigational Systems and Equipment. Retrieved from <https://www.lisr.com>
- [8]. London P&I Club. (2024). VDR Guidance for Members. Casualty Returns and Analysis.
- [9]. Maritime and Coastguard Agency. (2024). MGN 610 (M+F) Amendment 1: Navigation - SOLAS Chapter V - Guidance on the Merchant Shipping (Safety of Navigation) Regulations 2020. United Kingdom.
- [10]. Marine Insight. (2024). What is a Course Recorder on Ships? Retrieved from <https://www.marineinsight.com>

SUPPLEMENTARY MATERIAL

➤ *Appendix A: VDR Mandatory Recording Parameters*

Per IMO Resolution MSC.163(78), VDRs must record the following minimum data items:

Item	Description
1	Date and time
2	Ship’s position (latitude and longitude)
3	Speed
4	Heading
5	Bridge audio (conversations)
6	VHF radio communications
7	Radar display (12-inch capture or equivalent)
8	Depth under keel (echo sounder)
9	Main alarms
10	Rudder order and response
11	Engine order and response
12	Hull openings status
13	Watertight and fire door status
14	Accelerations and hull stresses
15	Wind speed and direction

- Note: Items highlighted in bold (heading and echo sounder data) directly duplicate parameters recorded by standalone course recorders and echo sounders, creating functional redundancy.

➤ *Appendix B: S-VDR Mandatory Recording Parameters*

Per IMO Resolution MSC.163(78), Simplified Voyage Data Recorders (S-VDRs) must record the following core mandatory data items:

Item	Description
1	Date and time
2	Ship’s position (latitude and longitude from GPS/GNSS)
3	Speed
4	Heading
5	Bridge audio (continuous recording from microphones on bridge)
6	VHF radio communications (relating to ship operations)
7	Radar display images (every 15 seconds) OR AIS target data (if radar interface unavailable)

- Conditional/Optional Parameters: - Echo sounder (depth under keel): Only recorded if standard interfaces are available.
- Key Distinction from Full VDRs: S-VDRs do not mandatorily record rudder orders, engine orders, hull openings, watertight doors, hull stresses, or wind data. However, S-VDRs ALWAYS record heading data (Item 4 in bold), creating identical redundancy with course recorders as full VDRs, regardless of vessel age or equipment configuration.

➤ *Appendix C: Summary of Search Terms and Results*

Search Domain	Result Summary
IMO GISIS Database	No circulars found addressing equipment redundancy.
Classification Society Publications	VDR rules identified; no guidance on superseding course recorders.
Flag State Websites	Marine guidance notes located; no equipment redundancy interpretations.
Academic Journal Databases	Zero peer-reviewed articles on topic.
Industry Association Publications	General VDR guidance; no redundancy analysis.
P&I Club Circulars	VDR data preservation emphasis; course recorders not mentioned.