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FROM ISOLATED INSPECTIONS TO SYSTEMIC COMPLIANCE: A METHODOLOGICAL FRAMEWORK FOR ADDRESSING SAFETY, REGULATORY, AND WORKFORCE GAPS IN MARITIME AND OFFSHORE OPERATIONS

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Abstract: The U.S. maritime and offshore sectors face converging operational pressures: the active fleet is aging, regulatory requirements are intensifying both domestically and internationally, and the technical workforce faces persistent skill gaps. Traditional inspection and compliance practices, typically carried out as isolated events and dependent on individual expertise, are structurally insufficient to address these large-scale systemic challenges. This article presents the Maritime Operational Compliance and Integrity Framework (MOCIF), a structured, modular, and replicable methodology developed from direct practical experience in maritime and offshore operations in the United States. MOCIF integrates technical diagnostics, regulatory risk mapping, standardized inspection protocols, corrective action planning, and workforce development into a continuous operational system. The article contextualizes these challenges within the U.S. environment, demonstrates how MOCIF addresses them with concrete mechanisms, and presents field evidence validating its practical feasibility. The framework was designed for scalable implementation among vessel operators, shipyards, classification societies, and stakeholders in the offshore energy sector, directly contributing to national objectives for maritime safety, environmental management, and offshore energy reliability.

Keywords: maritime safety; offshore inspection; regulatory compliance; MOCIF; technical workforce; fleet aging.

Introduction

Maritime and offshore infrastructure is critical to the economic competitiveness and national security of the United States. Offshore floating units, long-haul vessels, and offshore support units collectively sustain oil and gas production, cargo logistics, and, increasingly, offshore renewable energy generation. The reliability and safety of these assets are not peripheral concerns; they are strategic imperatives.

However, structural evidence points to a progressive deterioration in the fleet's operational conditions. According to a report published by DNV in 2025, maritime safety incidents increased by 42% between 2018 and 2024, while the global fleet grew by only 10% during the same period (DNV, 2025). Vessels over 25 years old accounted for 41% of all incidents recorded in 2024, representing a significant increase compared to the previous decade.

The U.S.-flagged vessel fleet is relatively small compared to the global scale, making the safety and operability of each individual asset more critical (UNITED STATES MERCHANT MARINE, 2024). Aging hulls and systems, increasing regulatory demands, and a limited fleet renewal rate combine to create a sector under mounting pressure.

Despite this context, inspection and compliance practices in the sector often remain fragmented: they are carried out as discrete events, without integration into long-term asset management strategies. Variability among inspectors, incomplete documentation, and disjointed tracking of corrective actions are persistent characteristics of the current operational environment.

This article presents the Maritime Operational Compliance and Integrity Framework (MOCIF) as a response to these systemic challenges. The framework was developed through direct professional engagement with maritime and offshore operations in the United States and inspections at shipyards during dry-docking periods. MOCIF is designed to be institutionalized, teachable, auditable, and scalable, in collaboration with operators, shipyards, and regulatory bodies.

The American Challenge: Aging Assets, Regulatory Complexity, and Workforce Shortages

Structural Risk Arising from Fleet Aging

The age profile of the U.S. maritime fleet is a key factor in operational and safety risk. As vessels age, structural fatigue accumulates in hull plates and bulkheads; propulsion systems and machinery experience increasing failure rates; firefighting, rescue, and pollution prevention equipment becomes obsolete; and the probability of unplanned downtime increases.

DNV's analysis confirms that machinery damage or failure has become the leading cause of maritime incidents globally, with a disproportionate concentration on older vessels (DNV, 2025). For U.S. operations, where regulatory oversight is intense and the environmental and commercial consequences of failures are severe, the risk profile of an aging fleet is particularly critical.

Without a systematic and forward-looking approach to condition assessment and maintenance planning, operators face a reactive cycle: deterioration leads to failure, failure leads to unplanned repairs, and unplanned repairs lead to prolonged downtime and regulatory scrutiny.

Regulatory Complexity and Documentation Gaps

The regulatory environment governing U.S. maritime and offshore operations is among the most demanding in the world. Domestic requirements enforced by the U.S. Coast Guard, including Title 46 of the Code of Federal Regulations (46 CFR), overlap with international obligations established by SOLAS, MARPOL, ISM, ISPS, MLC, and other IMO conventions. Offshore units face additional oversight through the CVA regime, which requires independent technical verification in accordance with approved engineering plans.

The U.S. Coast Guard's annual Port State Control (PSC) reports document the persistence of non-compliance issues. In 2022, 8,706 SOLAS safety inspections were conducted, resulting in 78 vessel detentions—an increase from the 63 detentions recorded the previous year—due to deficiencies in environmental protection, safety, and security measures (USCG, 2023). The data illustrates that even frequent inspections do not guarantee consistent compliance results.

The root cause is structural: when documentation is inconsistent, inspection methodologies vary among professionals, and findings are not systematically translated into corrective actions, the regulatory framework cannot produce reliable results

regardless of its rigor. Compliance becomes event-driven rather than systemic.

Workforce Capacity and Knowledge Retention

The technical demands of maritime and offshore compliance are significant. Inspectors and surveyors must apply complex and overlapping regulatory standards to diverse types of vessels and operational environments; produce consistent and auditable documentation under operational time pressure; and translate technical findings into actionable recommendations that operators and shipyards can realistically implement.

In fact, this knowledge is highly concentrated in experienced individuals and is rarely codified into transferable processes. When these professionals leave organizations, or when new inspectors join without structured mentoring programs, the institutional knowledge that underpins compliance consistency is lost.

This dynamic has direct operational consequences. Port State control data indicate that deficiencies related to maintenance, documentation, and safety systems are among the most frequently recorded, a pattern consistent with inconsistency at the workforce level, and not just with asset-level failures.

The Maritime Operational Compliance and Integrity Framework (MOCIF)

MOCIF was developed in response to the three interconnected challenges described above. It is a structured, modular methodology that transforms inspection and

compliance from reactive, event-driven activities into a continuous, evidence-based operational cycle. The framework is organized around five integrated modules.

Module 1 - Assessment of Technical Condition and Regulatory Risk

The diagnostic module initiates a comprehensive assessment of the physical condition of each asset and its corresponding regulatory exposure. Structural integrity assessments cover hull plates, bulkheads, and thickness measurements in accordance with classification standards. Machinery and propulsion systems are evaluated for current operability and risk of failure. Firefighting, lifesaving, and pollution prevention equipment is checked for functionality and certification status.

Simultaneously, a regulatory mapping exercise identifies all domestic and international requirements applicable to the specific asset type, flag state, and operational context, including USCG regulations, Class Rules, SOLAS, MARPOL, ISM, ISPS, MLC, and, where applicable, the MODU Code and CVA supervision requirements under 46 CFR.

The result is a technical-regulatory risk matrix: an objective prioritization of findings linked to their significance for human safety, the environment, structural integrity, and operation. This matrix provides the evidentiary basis for subsequent planning and corrective actions, while also serving as auditable documentation for insurers, classification societies, and regulatory authorities.

Module 2 - Operational Readiness Planning and Service Life Extension Strategy

Based on the diagnostic results, this module develops a comprehensive corrective action and service life extension plan. Findings are classified by criticality level, and corrective actions are sequenced to align with operational windows—minimizing downtime and ensuring that priority deficiencies are addressed before they worsen.

Dry-docking schedules are optimized to consolidate maintenance activities, reducing the cumulative impact on vessel availability. Long-term strategies for structural and systems life extension are developed to enhance the certifiability and commercial viability of assets beyond what reactive maintenance could achieve.

This module redefines regulatory compliance as a business tool, not a cost center: proactive planning reduces unplanned downtime, avoids emergency repair costs, and extends the productive life of capital assets.

Module 3 - Structured Inspection Execution and Evidence Documentation

This module standardizes the field execution of inspections. Instead of relying on the inspector's individual judgment to determine scope and documentation format, MOCIF provides structured checklists, photographic documentation protocols, non-destructive testing procedures (including ultrasonic thickness measurement), and functional testing standards for critical systems.

Digital tools—including remote monitoring systems, predictive analytics pla-

forms, and inspection management software—are integrated where applicable, aligning the inspection process with evolving industry practices and enabling real-time data capture and trend analysis.

The result is a consistent and traceable audit trail that reduces variability among inspectors, improves the defensibility of findings, and supports reliable decision-making among stakeholders.

Module 4 - Compliance and Corrective Action Communication Protocol

Inspection findings, however comprehensive they may be, only deliver value when they drive effective corrective actions. This module transforms technical inspection reports into structured, actionable corrective plans. Each finding is documented with: its specific significance for safety, the environment, or regulations; the recommended corrective action; a realistic implementation timeline; and the standard of evidence required to demonstrate closure.

This approach eliminates the ambiguity that often characterizes dense technical inspection reports and establishes clear accountability among surveyors, operators, and shipyards. It also improves communication with regulatory authorities and insurers, who require unequivocal evidence of compliance, not technical narratives.

Module 5 - Knowledge Transfer and Internal Training

The final module directly addresses the workforce capacity challenge. MOCIF establishes replicable training programs, standardized technical reference materials, and structured mentoring protocols for new

professionals. The Train-the-Trainer model allows organizations to internalize the methodology and sustain it without reliance on external experts.

Standardized technical language, calibrated against applicable regulatory frameworks, reduces interpretive variability that produces inconsistent inspection results across organizations and operational contexts.

The cumulative effect is institutional: organizations develop a durable and internally sustainable culture of compliance and technical rigor, which reduces workforce fragility and strengthens long-term operational resilience.

National Relevance and Strategic Alignment

The challenges that MOCIF addresses are not peripheral operational concerns—they are matters of national importance. The consequences of failing to resolve them ripple throughout the maritime and offshore sectors.

Safety failures at sea impose human, environmental, and economic costs that ex-

tend far beyond individual operators. Environmental incidents in U.S. coastal and offshore areas have consequences for protected ecosystems, fishing communities, and public health. Vessel detentions reduce cargo flow and disrupt supply chains dependent on maritime logistics. Compliance failures on offshore energy platforms affect energy production and revenue generation in strategically important areas.

MOCIF offers a structured path to systematically reduce these outcomes. Its implementation among operators, shipyards, and stakeholders in the U.S. offshore energy sector would yield measurable improvements in the areas presented in Table 1.

In addition to its operational benefits, MOCIF aligns directly with stated U.S. policy priorities. The U.S. Coast Guard's strategic emphasis on consistent port state control outcomes, classification societies' technical standards for the safe construction and operation of vessels, and the IMO's global framework for maritime safety and environmental protection reflect the systemic approach that MOCIF institutionalizes.

As the U.S. maritime sector expands into offshore wind energy, hydrogen logis-

Impact Area	Expected Outcome
Fleet Safety	Reduction of mechanical failures, structural incidents, and environmental spills through proactive diagnostics and maintenance planning
Regulatory Compliance	Reduction in detention rates and exposure to penalties through consistent documentation and corrective action protocols
Offshore Energy Reliability	Improved operational continuity on production platforms and OSVs that support the U.S. energy supply
Workforce Development	Faster onboarding and greater consistency among new maritime professionals through standardized training frameworks
Digital Integration	Better alignment with smart asset management and predictive maintenance technologies as the industry modernizes

Table 1 - Areas of National Impact of MOCIF

Source: Prepared by the author (2025).

tics, and alternative-fuel transportation—domains that will require entirely new paradigms of compliance and verification—an adaptable and structured framework for operational integrity becomes more, not less, strategically essential.

Conclusion

The maritime and offshore industries operating under U.S. jurisdiction face structural challenges that cannot be resolved by regulatory intensity alone. An aging fleet, a complex and evolving regulatory environment, and high technical demands on the workforce create conditions in which fragmented, event-driven inspection practices are systematically insufficient.

The Maritime Operational Compliance and Integrity Framework (MOCIF) offers a structured, evidence-based, and institutionally replicable approach. By integrating technical diagnostics, regulatory mapping, standardized inspections, corrective action planning, and workforce development into a continuous operational methodology, MOCIF transforms compliance from a reactive necessity into a proactive strategic asset.

The widespread adoption of structured methodologies such as MOCIF in U.S. maritime and offshore operations represents a concrete opportunity to improve national safety outcomes, strengthen regulatory compliance systems, and build a more capable and resilient maritime and offshore workforce—outcomes that align directly with U.S. strategic priorities in maritime safety, energy security, and environmental protection.

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