A Thought Leadership White Paper

# FROM PAPER TO TRUST

## MODERNISING MARPOL DOCUMENTATION

How Ports Can Become the Control Layer of Digital Maritime Compliance

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# Executive Summary

The maritime industry is entering a decisive phase of digital transformation. Over the past decade, the International Maritime Organization has established the regulatory foundations for digital documentation through the mandatory Maritime Single Window and new guidelines enabling the use of electronic certificates.

Despite regulatory progress, MARPOL compliance at the port–ship interface remains largely paper-based, where record books, certificates and waste delivery receipts are still exchanged and verified manually during port calls. This persistence of paper processes results in avoidable inefficiencies, limited data transparency and weak verifiability of compliance records for Port and Maritime Administrations.

This white paper argues that Port Authorities and Port Reception Facilities can act as the operational trigger to accelerate the transition toward digital MARPOL documentation. Because every vessel interacts with the port–ship interface during each port call, ports represent the most effective point at which digital workflows can be introduced and scaled across the industry.

By enabling digital waste notifications, issuing electronic waste delivery receipts and supporting trusted verification of maritime certificates, ports can establish the operational foundations for secure and interoperable MARPOL documentation.

The regulatory framework is already in place. Technology is mature and ready to support trusted digital records. What is now required is coordinated implementation — starting at the port–ship interface.

### Central Argument

Ports and PRFs occupy a unique leverage position in MARPOL compliance. Their role enables three critical functions:

- Standardisation — enforcing structured digital workflows at every port call.
- Validation — acting as the first point of verification for compliance data.
- Network activation — creating adoption pressure across ship operators and flag states.

By digitising high-frequency interactions, ports can trigger a network effect that accelerates adoption across the maritime ecosystem.

# 1. Introduction: The Compliance Paradox

## 1.1 A Framework Built for Paper

MARPOL's six annexes collectively require dozens of distinct documents, certificates, and record books. These range from the International Oil Pollution Prevention (IOPP) Certificate under Annex I, through cargo record books for noxious liquid substances under Annex II, sewage pollution prevention certificates under Annex IV, garbage management plans and record books under Annex V, to the International Air Pollution Prevention Certificate and Bunker Delivery Notes under Annex VI. Each document serves a compliance and enforcement function, yet nearly all are generated, carried, and exchanged in paper form.

The administrative burden is substantial. A single vessel calling at a port may be required to present, exchange, or update multiple MARPOL documents across different regulatory bodies — port state control (PSC) officers, port authority inspectors, customs officials, and PRF operators — often within a narrow window of port turnaround time. Research presented at IMO's Facilitation Committee (FAL 48, April 2024) found that on average, port call document preparation consumes over three hours per call, with 64% of ports still requiring paper or mixed paper-digital submissions despite the MSW mandate (IMO & BIMCO survey, 2024). That is, digitally enabled regulation, analog execution.

The status quo is not merely inefficient — it creates enforcement vulnerabilities. Paper-based records can be altered, misdated, or fabricated. Cross-checking across annexes and across voyages is time-consuming and often impractical within port turnaround schedules. The integrity of the MARPOL regime depends in part on the reliability of its documentation, and paper documentation is not only inefficient — it is structurally incompatible with scalable, data-driven enforcement.

## 1.2 The Stakes at the Port–Ship Interface

For Ports (Port Authority — Maritime Authority or competent public body responsible for regulating, managing and overseeing port operations), and PRFs in particular, the documentation burden has direct operational consequences. Under MARPOL Annex I, II, IV, V, VI PRFs are required to issue a delivery receipt when a vessel delivers any kind of waste.

| Annex | Subject | Key Documents | Certificate Authority | Port/PRF Relevance |
|---|---|---|---|---|
| **Annex I** | Oil & Oily Water | Oil Record Book (Parts I & II) | Mandatory – flag state issued | High – ship/PRF interface daily |
| **Annex II** | Noxious Liquid Substances | Cargo Record Book, P&A; Manual | Flag state certified | Medium – specialised tankers |
| **Annex IV** | Sewage | ISPP Certificate | Flag state issued | Low – limited PRF infrastructure |
| **Annex V** | Garbage | Garbage Management Plan, Garbage Record Book | Crew-maintained record | High – all vessels, every port call |
| **Annex VI** | Air Pollution & Emissions | IAPP Certificate, BDN, CII/SEEMP, EEXI | Flag state issued; IMO DCS data | High – compliance verification growing |

***Table 1: MARPOL Annexes — Key Documents for the Vessel and Port/PRF Relevance***

These workflows create daily friction:

- Manual re-entry of operational data
- Physical exchange and storage of receipts
- No real-time verification of ship documentation
- No linkage between delivered waste and record books

For port authorities attempting to use MARPOL compliance data for environmental monitoring, planning, or reporting, the data is largely inaccessible in any structured digital form.

The PRFs are obliged to report all the data to the port and maritime authority once the service is completed and this reporting is largely manual across ports. In some ports this is semi-automated by means of entries made to the port community systems (PCS). The PRF needs to upload the delivery receipts to the PCS (where available) in order to get paid. This process is far from being efficient and defeats the goal of a connected digital port.

As a result, the same compliance event is recorded multiple times across disconnected systems, with no single source of truth.

# 2. The Regulatory Readiness of Maritime Digitalisation

## 2.1 The Maritime Single Window — A Mandatory Foundation

Since 1 January 2024, all IMO member states are legally required under the FAL Convention (Resolution FAL.14(46)) to operate a Maritime Single Window (MSW): a centralised digital platform for collecting and exchanging information between ships and port authorities during port calls. This is a watershed moment, not because the MSW itself digitalises MARPOL documentation, but because it establishes the data infrastructure and political mandate for all port call information exchange to migrate to digital channels.

The MSW requirement means that, in principle, ports already have a digital channel through which MARPOL-related notifications and documentation can flow. The FAL Convention's standard forms include the Advance Notification for Waste Delivery to Port Reception Facilities (MEPC.1/Circ.834/Rev.1), which is explicitly listed as one of the standard documents to be transmitted through the MSW. The challenge is that implementation remains uneven: many member states have MSW systems that are technically compliant but narrowly scoped, covering only the minimum arrival and departure formalities, while MARPOL documentation upon delivery continues to sit outside the digital pipeline.

## 2.2 Electronic Certificates — The IMO's Evolving Framework

The IMO has been developing guidelines for electronic certificates through multiple parallel workstreams. FAL.5/Circ.39/Rev.2 established early guidance on the use of electronic certificates, and MEPC resolution MEPC.312(74) provided specific guidance on electronic record books under MARPOL. Most recently, at FAL 49 in March 2025, a landmark joint circular was approved: the FAL-LEG-MEPC-MSC Guidelines for the use of electronic certificates, now awaiting concurrent approval by MEPC 83 and MSC 110.

This new consolidated guidance represents the IMO's most comprehensive statement yet on what electronic certificates must contain and how they should function. Key requirements include:

- Unique identity
- Integrity protection
- Verifiability
- Standard format

Flag administrations will be required to communicate which certificates they will issue in electronic form, creating a registry of digital certificate capability across the global fleet.

In parallel, the IMO's broader digitalisation strategy — targeting adoption by the IMO Assembly in 2027 — is tasking all major committees, including MEPC (environment) and FAL (facilitation), to integrate digitalisation into their regulatory development processes. This signals that digital-first documentation is not a future aspiration but an active near-term policy objective.

The IMO has effectively solved the question of what a digital certificate must be — but not yet how it should be operationally used at the port interface.

**Key IMO Instruments for Digital MARPOL Documentation**

- FAL Convention (as amended, in force Jan 2024): Mandatory MSW for all member states.
- MEPC.312(74): Guidelines on electronic record books under MARPOL.
- MEPC.1/Circ.834/Rev.1: Advance notification for waste delivery — listed as standard MSW document.
- MSC-FAL.1/Circ.3/Rev.3 (2025): Updated guidelines on maritime cyber risk management.
- FAL-LEG-MEPC-MSC.1/Circ.1 (2025, pending): Joint consolidated guidelines for electronic certificates. IMO Digitalisation Strategy (target: 2027): Overarching framework for maritime
- digitalisation
  across all IMO bodies.

# 3. The Coordination Challenge in MARPOL Digital Transition

## 3.1 A System-Level Adoption Barrier

The transition toward digital MARPOL documentation is not primarily constrained by technology or regulatory intent. Rather, it is shaped by a structural coordination challenge across the maritime compliance ecosystem.

Digital documentation in the maritime sector requires interaction between multiple independent actors: ship operators, flag administrations, classification societies, port authorities, port state control regimes, and Port Reception Facility providers. Each stakeholder plays a distinct role within the regulatory architecture.

However, the value of digital certificates and records increases significantly only when they are recognised and accepted across this broader network.

In practice, this interdependence has created a situation in which progress depends on simultaneous adoption. Ship operators may hesitate to invest in digital systems if ports cannot receive or verify electronic documentation. Ports may hesitate to invest in digital infrastructure if vessels continue to rely on paper processes. Flag administrations may prioritise electronic issuance when there is clear operational demand from both sides of the interface.

As a result, despite clear regulatory advancements and available technological solutions, adoption remains uneven across jurisdictions.

This dynamic reflects a classic network adoption problem: no single actor can fully realise the benefits of digitalisation without complementary action by others.

### 3.2 Regulatory Progress Without Operational Convergence

The International Maritime Organization has progressively established the regulatory foundations for electronic documentation. However, regulatory enablement does not automatically translate into operational convergence. While electronic certificates are increasingly recognised in principle, their implementation varies significantly between flag states. Similarly, ports are not universally required to receive or verify digital certificates as part of their standard procedures.

This asymmetry contributes to gradual adoption rather than systemic transformation. Digital transition in MARPOL documentation therefore requires not only regulatory clarity, but also practical implementation at a consistent operational interface.

### 3.3 The Need for an Initiating Catalyst

In complex international systems, transformation often begins at the point of highest interaction frequency. In the case of MARPOL compliance, that point is the port–ship interface.

Unlike periodic surveys or selective inspections, the port call occurs during every voyage and involves direct exchange of compliance documentation. This recurring operational event creates an opportunity to introduce structured digital workflows at the most consistent and universal touchpoint in the maritime compliance chain.

## 4. Ports as the Operational Catalyst

Port Authorities and Port Reception Facilities are uniquely positioned to act as initiating catalysts for digital MARPOL documentation. Their position within the maritime compliance architecture grants them a structural advantage that other actors do not share.

Every vessel — regardless of flag state, operator, or classification society — must interact with a port during a port call. The port call is therefore the universal interface through which digital documentation requirements can be applied consistently and at scale.

Within the existing regulatory framework, Ports and Port Reception Facilities can progressively implement structured electronic documentation processes, aligned with IMO guidelines for electronic certificates and digital information exchange standards as defined in the IMO Compendium and GISIS which a harmonised data framework for ship-port information is defined.

By focusing on the operational touchpoint where compliance is actively verified, ports can initiate transformation from within the system rather than relying on external actors to move first. This positions ports as practical enablers of digital convergence across the maritime sector.

# 5. Digital Trust for Maritime Compliance

## 5.1 From Digital Format to Verifiable Integrity

The digitisation of compliance documentation is an important step, but format alone does not guarantee trust. A scanned document, a static PDF, or an email-based certificate may improve accessibility, but it is not truly digital and it does not inherently resolve challenges related to authenticity, version control, traceability, or long-term auditability. In multi-stakeholder environments such as MARPOL workflows, these properties are essential.

The objective is therefore not simply to replace paper with electronic files, but to ensure that digital records are:

- Authenticated at source
- Protected against unauthorised modification
- Traceable to their issuer
- Verifiable independently by authorised parties
- Suitable for cross-border recognition

Without these safeguards, digital systems risk replicating traditional inefficiencies in electronic form. Digital transformation in maritime compliance must therefore focus on integrity and verification rather than format alone.

## 5.2 Regulatory Functional Requirements

International guidance on electronic maritime documentation establishes clear functional criteria. Electronic certificates and records must include:

- A unique identifier
- Protection against alteration
- Recognised and accepted formatting
- Clear verification mechanisms
- Secure issuance and storage processes

Importantly, these guidelines are technology-neutral. They define the properties required for compliance but do not prescribe specific technical architectures. This approach allows Member States, ports, and industry actors to adopt solutions that meet regulatory requirements while maintaining interoperability and legal recognition across jurisdictions.

The emphasis is therefore on meeting defined functional standards, not on implementing a particular technology.

## 5.3 Distributed Ledger Architectures as One Implementation Option

Among the available technical approaches, distributed ledger architectures are particularly well-suited to multi-party compliance environments where integrity, traceability, and shared verification are required. They enable:

- Time-stamped and sequentially recorded transactions
- Controlled access among authorised participants
- Tamper-evident data structures
- Shared visibility of validated information across stakeholders

These characteristics are especially relevant where multiple independent institutions must rely on a common, synchronised record without depending on a single central authority.

Distributed ledger technology should not be understood as a regulatory requirement, nor as the only viable implementation model. Rather, it represents one architectural approach capable of meeting the functional criteria defined by international guidelines for electronic documentation.

The core principle remains unchanged: MARPOL compliance systems must ensure verifiable authenticity, integrity, and auditability of records, regardless of the underlying technology.

## 5.4 Trust as Infrastructure, Not Technology

The broader objective is to establish a digital trust infrastructure that supports secure information exchange across the maritime ecosystem.

Whether implemented through distributed systems, secure databases, interoperable platforms, or other recognised architectures, the essential requirement is that documentation can be independently verified, audited, and recognised across jurisdictions.

By focusing on functional compliance and institutional trust rather than on specific technologies, maritime stakeholders can progressively modernise workflows while remaining aligned with international regulatory frameworks.

In this sense, digital trust architectures are not an end in themselves, but an enabling layer that supports transparency, interoperability, and long-term system coherence.

# 6. Industry Implications

## 6.1 Interoperability and Standards

The single greatest technical barrier to MARPOL digitalisation at the port level is the absence of universal interoperability standards for electronic maritime certificates and records. Ports risk building digital systems that cannot communicate with flag state registries, ship management systems, or the MSW platforms of other ports. The IMO Compendium provides a partial answer — aligning to its data standards reduces interoperability risk — but it does not fully specify DLT architecture or certificate formats.

The prudent approach is to build on open, maritime-sector standards where they exist (such as DCSA's data standards for container shipping, or the IMO Compendium's reference models) while engaging actively with IMO and regional port authority bodies to shape the standards that are still being developed. Early adopters who participate in standards development will shape outcomes to their advantage; late adopters will implement standards shaped by others.

## 6.2 Legal Recognition and Acceptance

While the IMO framework increasingly supports electronic certificates, the legal status of digital MARPOL documents varies significantly across jurisdictions. Some flag states formally recognise and issue electronic versions of MARPOL certificates; others do not. Port state control procedures for inspecting electronic records are not yet standardised. Ports that accept digital documents need clear internal protocols for what constitutes a valid electronic certificate and how discrepancies are handled.

This challenge is real but navigable. The new joint IMO guidelines (FAL-LEG-MEPC-MSC.1/Circ.1) provide a basis for ports to define acceptance criteria for electronic certificates. Working with port state control authorities, classification societies, and the flag state community to develop clear acceptance protocols — and advocating within the Paris MOU, Tokyo MOU, and other regional PSC organisations for harmonised approaches — is a concrete and high-value industry action.

## 6.3 Cybersecurity

Any digital infrastructure for maritime compliance documentation is a potential cybersecurity target. The IMO has updated its maritime cyber risk management guidelines (MSC-FAL.1/Circ.3/Rev.3, 2025), and resolution MSC.428(98) already requires shipping companies to address cyber risks in their safety management systems. For ports, a DLT architecture — by its nature distributed and without a single point of failure — offers inherent cybersecurity advantages over centralised database approaches. Nevertheless, robust key management, access control, and regular security auditing are essential design requirements for any maritime blockchain system.

## 6.4 Capacity and Cost

Smaller Ports and PRFs, particularly in developing maritime nations, may lack the technical capacity or financial resources to invest in DLT infrastructure. This is a genuine equity challenge for the industry. Regional cooperation — where a port community system provider operates a shared DLT node on behalf of multiple smaller ports — and international technical assistance, including through IMO's Integrated Technical Cooperation Programme, are mechanisms through which the benefits of digitalisation can be extended equitably across the port community.

# 7. A Call to Action: Leadership at the Port Interface

The maritime industry no longer faces a question of feasibility, but of execution. Paper-based MARPOL documentation is widely recognised as inefficient, vulnerable to manipulation, and incompatible with the data requirements of modern environmental regulation. The regulatory direction is clear, and the enabling technologies are mature.

What remains unresolved is implementation at scale.

This paper has argued that the most effective point to initiate that transition is the port–ship interface. Ports and Port Reception Facilities are uniquely positioned to introduce structured digital workflows at the moment where compliance is operationally verified and recorded.

This is not merely an operational upgrade. It is a strategic opportunity.

Ports that take the lead in digital MARPOL compliance will strengthen their role within the maritime ecosystem — enhancing trust with port state control authorities, increasing attractiveness to digitally mature shipping operators, and enabling data-driven environmental oversight. In doing so, they will move from being passive checkpoints to active enablers of compliance integrity.

The transition will not occur spontaneously. It requires deliberate leadership.

## Recommended Actions for Ports and PRFs

- **Establish a MARPOL digitalisation working group** — Bring together PRF operators, port state control authorities, port community system providers, and key shipping stakeholders to align on objectives, scope, and governance.
- **Launch a first-phase operational pilot** — Prioritise high-frequency workflows such as waste advance notifications, digital waste delivery receipts, or electronic certificate verification. Define clear scope, timelines, and measurable success criteria.
- **Define acceptance and verification protocols** — In coordination with port state control and flag administrations, establish clear criteria for recognising and validating electronic documentation.
- **Align with international and regional frameworks** — Engage with the International Maritime Organization, regional Port State Control regimes (e.g. Paris MOU, Tokyo MOU), and national authorities to contribute to emerging standards and ensure interoperability.
- **Invest in scalable digital infrastructure** — Build on the Maritime Single Window and extend capabilities toward interoperable, verifiable data exchange across port community systems.
- **Promote transparency and knowledge sharing** — Document pilot outcomes and share learnings through industry bodies such as IAPH, IPCSA, and BIMCO to accelerate industry-wide adoption.

## 7.1 The Annex-by-Annex Opportunity: A Sequenced Approach

The transition to digital MARPOL documentation does not require simultaneous implementation across all annexes. A sequenced approach — prioritising high-frequency and high-impact workflows — enables rapid value creation while reducing implementation complexity.

| Phase | Focus | Description |
|---|---|---|
| 1 | **High Frequency, Immediate Impact** | Annex V (Garbage). Applies to all vessels on every voyage. Waste delivery receipts are standardised, frequent, and operationally simple — making them ideal for immediate digitalisation. |
| 2 | **High Volume, High Verification Value** | Annex I (Oil). Oily water and sludge deliveries are frequent and tightly regulated. Digital records significantly improve traceability and reduce verification gaps between PRFs and vessel record books. |
| 3 | **High Regulatory and Commercial Impact** | Annex VI (Air Emissions). Increasingly central to both regulatory scrutiny and commercial decision-making. Digitalisation of bunker delivery notes, CII-related data, and SEEMP verification enables higher levels of transparency and auditability. |
| 4 | **Specialised Workflows** | Annex II (NLS) and Annex IV (Sewage). More limited in scope and dependent on specialised infrastructure. These can follow once core digital workflows are established. |
| 5 | **Systemic Integration and Data-Driven Compliance** | Once digital workflows are established across annexes, the focus shifts from individual process digitalisation to full system integration. At this stage, ports transition from digitising documents to orchestrating a connected compliance ecosystem. |

At a systemic level, this enables:

- Cross-annex verification and consistency checks (e.g. alignment between waste delivery and record books).
- Real-time visibility for port authorities and regulators.
- Automated reporting to national authorities and international systems such as IMO platforms (e.g. GISIS).
- Advanced analytics for environmental monitoring, anomaly detection, and risk-based inspections.

At a systemic level, the port evolves into a trusted node within a broader digital compliance network — where data integrity, interoperability, and verification are embedded by design.

### The Opportunity is Real and Present

The transition to digital MARPOL documentation is no longer a matter of policy development or technological capability. It is a question of operational leadership.

Ports that act now will not only improve efficiency within their own operations — they will define the standards, practices, and expectations that shape the future of maritime compliance.

The question is no longer whether this transition will occur, but where it will begin — and who will lead it.

# Glossary of Key Terms

**BDN**

Bunker Delivery Note — document required under MARPOL Annex VI certifying fuel oil sulphur content and other properties at bunkering.

**CII**

Carbon Intensity Indicator — MARPOL Annex VI metric measuring the annual carbon intensity of a ship's operations.

**DLT**

Distributed Ledger Technology — umbrella term for systems (including blockchain) that maintain shared, synchronised records across multiple nodes.

**EEXI**

Energy Efficiency Existing Ship Index — a one-time technical measure for existing ships under MARPOL Annex VI.

**FAL Convention**

Convention on Facilitation of International Maritime Traffic (1965) — governs ship clearance procedures and mandates the Maritime Single Window.

**GISIS**

Global Integrated Shipping Information System — IMO's centralised maritime data platform, including a module for survey and certification.

**IAPP Certificate**

International Air Pollution Prevention Certificate — required for ships ≥400GT under MARPOL Annex VI.

**IOPP Certificate**

International Oil Pollution Prevention Certificate — required for oil tankers ≥150GT and other ships ≥400GT

**ISPP Certificate**

International Sewage Pollution Prevention Certificate — required for ships engaged in international voyages.

**MEPC**

Marine Environment Protection Committee — IMO body responsible for MARPOL and environmental regulation.

**MSW**

Maritime Single Window — mandatory digital platform (since Jan 2024) for exchanging ship clearance information between ships, ports, and national agencies.

**PRF**

Port Reception Facility — facility that receives ship-generated waste and residues in accordance with MARPOL requirements.

**PSC**

Port State Control — Inspection regime by which port states verify that foreign ships comply with international maritime conventions.

**SEEMP**

Ship Energy Efficiency Management Plan — operational efficiency plan required under MARPOL Annex VI.