

# Designing Enterprise Architecture for Vessel Services: A Case Study of PT Pelindo Jasa Maritim

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## ABSTRACT

PT Pelindo Jasa Maritim (SPJM), as one of the subholdings of PT Pelabuhan Indonesia (Pelindo) providing marine and port supporting services, requires information technology to support service integration in line with the company's strategic directions. Using the TOGAF framework, this study identifies five main business service clusters: Marine Services (Pilotage and Towage), Crewing, Port & Equipment Services, Dredging & Shipyard, and Utilities. Each cluster is designed to be supported by a single standardized core application that reflects the strategic direction of "one main application per cluster." The proposed architecture combines a hybrid cloud approach with Internet of Things (IoT) technologies to enable advanced analytics and data-driven decision making. Data were collected through document analysis, interviews with key stakeholders, and observation of core business processes. This study adopts a Design Science Research (DSR) approach and evaluates the EA blueprint through expert-based validation against alignment, completeness, and implementation feasibility criteria. The study results in an enterprise architecture blueprint that defines the role of core applications for each service cluster and specifies the supporting technology platforms required to realize strategic directions. The design can serve as a reference for companies in the maritime industry..

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## 1. INTRODUCTION

The consolidation of Indonesian state-owned port operators into PT Pelabuhan Indonesia (Pelindo) created new requirements for standardisation and integration of business processes, data, and technology across the group. PT Pelindo Jasa Maritim (SPJM) was established as a sub-holding responsible for marine services, crewing, port equipment, dredging and shipyard, and utilities. Each legacy entity had previously developed its own applications and data structures, leading to duplication, inconsistent service quality, and difficulties in obtaining an enterprise-wide view of operations [1], [2], [3], [4], [5], [6].

Enterprise Architecture (EA) provides a structured approach to align business strategy, processes, information, applications, and technology. Previous studies have shown that a well-managed EA capability can improve strategy execution, reduce IT complexity, and enable digital transformation in large organisations. However, empirical research on EA in maritime logistics and port-service providers, especially in emerging economies, is still limited. At the same time, ports and maritime logistics are under pressure to digitalise their operations to increase efficiency, transparency, and resilience [7], [8], [9], [10], [11], [12].

This study addresses the following research question: How can enterprise architecture be designed for a maritime logistics sub-holding such as SPJM to support integrated, standardised

vessel services across multiple ports? The objective is to produce an EA blueprint that captures the target business processes, data entities, application landscape, and technology platform for SPJM's vessel-related services. The results are expected to support SPJM's digital transformation roadmap, enhance alignment with Pelindo's holding-level architecture, and provide a reference for similar organisations in the maritime sector [13], [14], [15].

This study contributes by (1) demonstrating the application of TOGAF-based enterprise architecture design in a maritime services sub-holding context, (2) proposing a cluster-based “one core application” principle to support integrated and standardised vessel services, and (3) providing a validated EA blueprint that bridges strategic planning documents and implementable architectural building blocks.

## 2. RESEARCH METHOD

This research adopts a design science research (DSR) approach, where the main artefact is the proposed enterprise architecture for SPJM's vessel services. DSR is appropriate because the study aims to design a purposeful solution to a relevant organisational problem [16], [17], while grounding the design in existing theories and frameworks in enterprise architecture and digital transformation [9].

Table 1. Comparison of EA Frameworks [12]

| Criteria                        | ZFEA      | DoDAF     | FEAF      | TOGAF     |
|---------------------------------|-----------|-----------|-----------|-----------|
| Adaptability                    | 3         | 2         | 3         | 3         |
| Scalability                     | 2         | 2         | 2         | 3         |
| Ease of Implementation          | 1         | 2         | 2         | 2         |
| Support for Modern Technologies | 2         | 3         | 1         | 3         |
| Cost-Effectiveness              | 3         | 2         | 2         | 2         |
| Compliance & Standards          | 2         | 3         | 2         | 3         |
| Traceability                    | 3         | 1         | 2         | 3         |
| Risk Management                 | 2         | 2         | 2         | 2         |
| <b>Total</b>                    | <b>18</b> | <b>17</b> | <b>16</b> | <b>21</b> |

Based on a published comparative evaluation of major EA frameworks across key criteria relevant to digital transformation (e.g., adaptability, scalability, modern-technology support, compliance, traceability, and risk management) as summarised in Table 1, TOGAF shows the strongest overall fit and balanced coverage in the referenced study. Accordingly, TOGAF is selected in this paper because it provides a complete, tailorable method (ADM) and a well-established set of deliverables to translate strategic objectives into an implementable target architecture in a multi-entity environment such as SPJM [14]. It is important to note that Table 1 is adopted from prior work [14], as supporting evidence and was not re-scored in this study. In the referenced study, the numeric scale indicates relative suitability of each framework per criterion (1 = low, 2 = moderate, 3 = high). In addition to this literature-based comparison, the final selection in this study was validated against SPJM's context and constraints, including required TOGAF ADM deliverables, traceability, and implementability, consistent with the Design Science Research orientation of this paper.

The TOGAF Standard (10th Edition) is used as the primary methodological guide. The Architecture Development Method (ADM) phases applied in this study include: (1) Preliminary and Architecture Vision, to understand SPJM's strategic context, value chain, and stakeholder needs; (2) Business Architecture, to define target processes and capabilities for each service cluster; (3) Information System Architecture, to design target data and application architectures; and (4) Technology Architecture, to specify the hybrid platform, integration mechanisms, and supporting infrastructure [13].

Data were collected through document review and semi-structured interviews. Interviews were conducted with stakeholders representing PT Pelindo (holding level) and PT Pelindo Jasa Maritim (SPJM), covering business operations, information technology, and enterprise architecture-related roles across the five service clusters and relevant corporate functions 4 functions. A purposive sampling strategy was applied to ensure coverage of key decision-making and operational perspectives. Each interview lasted approximately 60–90 minutes and followed a predefined protocol covering current processes, issues, pain points, and future requirements.

Evidence from documents and interviews was triangulated, and inconsistent viewpoints were addressed through follow-up interviews and cross-validation between holding-level and SPJM informants to reach a consolidated interpretation.

## 2.1. Design Science Research Evaluation

As this study follows a Design Science Research (DSR) paradigm, the proposed enterprise architecture artefact was evaluated using an expert-based evaluation approach to assess whether the designed EA addresses the identified organisational problem and meets its intended objectives.

The evaluation criteria included: (1) alignment with SPJM's strategic direction as defined in the RJPP 2025 – 2029, IT Masterplan 2023 – 2027, Pelindo Holding, and Danantara, (2) architectural completeness across business, data, application, and technology domains, (3) consistency with TOGAF ADM principles, and (4) feasibility for phased implementation within SPJM's organisational context.

## 3. RESULTS AND DISCUSSION

To structure the presentation of findings, this section begins with the Architecture Vision by clarifying SPJM vessel-services value chain and the service clusters that frame the target architecture. This provides the foundation for the subsequent domain designs in business, data, application, and technology.

### 3.1. Architecture Vision and Value Chain

SPJM's value chain for vessel services spans from order and contract management, through planning and execution of marine, crewing, equipment, dredging, and utility services, to billing and performance monitoring. Based on this value chain, five service clusters are defined as the primary organising units for the target architecture: Marine Service, Crewing, Port & Equipment, Dredging & Shipyard, and Utilities. Each cluster has its own specific processes and systems, but must also share common data and follow group-wide governance principles [1], [18], [19].

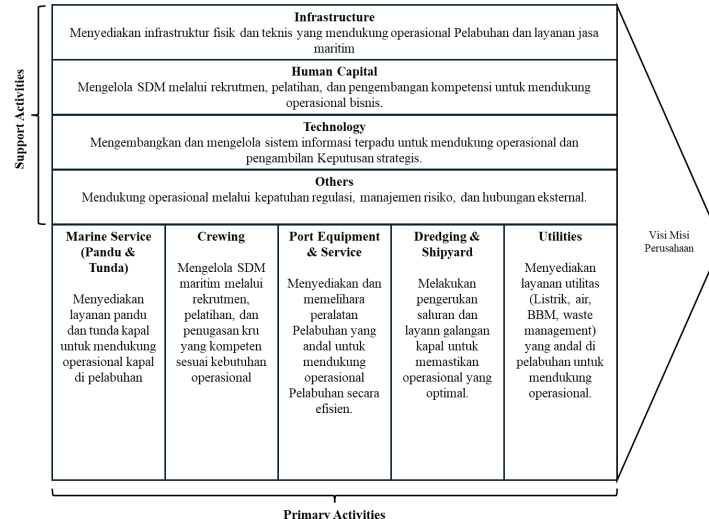


Figure 1. Value Chain Analysis

### 3.2. Business Architecture

For the Marine Service cluster, the target business architecture covers end-to-end processes such as service request registration, feasibility analysis, service planning and scheduling, resource allocation, execution and work logging, service completion, and billing. These processes are designed to support different types of marine services, including pilotage, towage, mooring, and other navigational services [1], [2], [20], [21].

The Crewing cluster focuses on the full lifecycle of seafarer management, from workforce planning, recruitment and onboarding, training and certification, assignment to vessels, to performance management and payroll. The Port & Equipment cluster covers planning, allocation, operation, and maintenance of port equipment and floating assets. The Dredging & Shipyard cluster governs project-based activities such as tendering, project planning, execution, and quality assurance. Finally, the Utilities cluster manages cross-cutting services such as energy and water supply, waste management, and ancillary services provided within port areas.

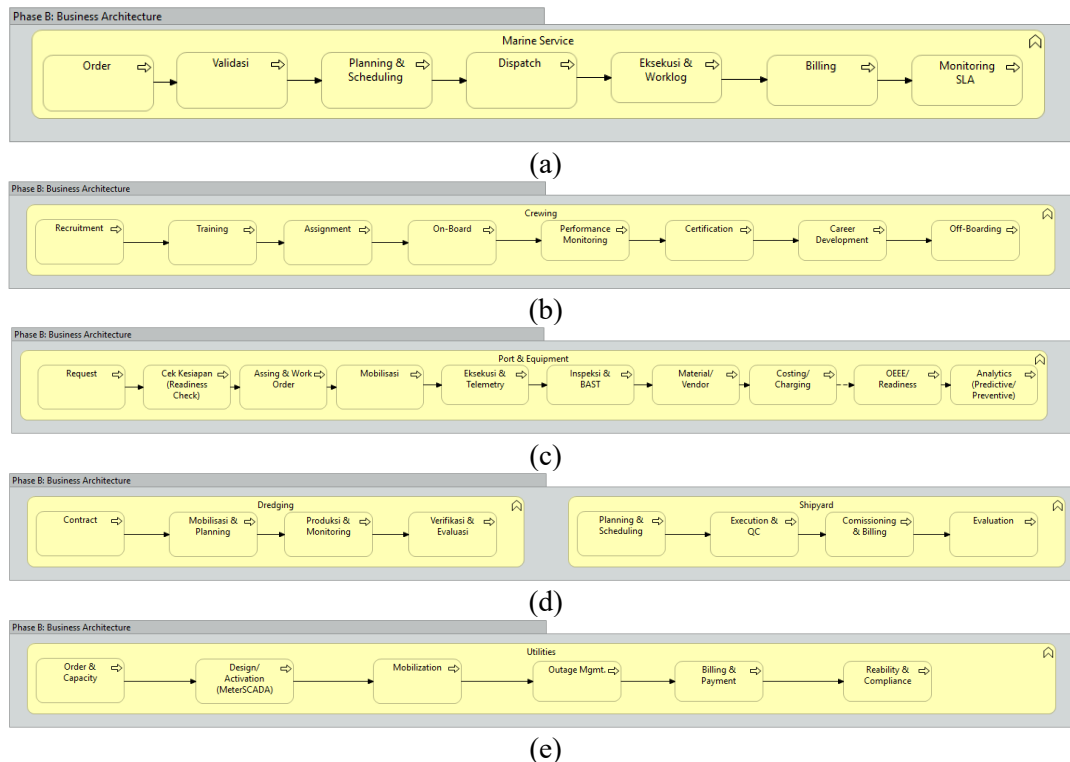


Figure 2. Business Architecture,  
(a) Marine, (b) Crewing, (c) Port & Equipment Service, (d) Dredging & Shipyard, (e) Utilities

### 3.3. Data Architecture

The data architecture defined in this study is positioned at the conceptual and logical enterprise architecture level. It focuses on identifying core data entities, their relationships, and their role in supporting cross-cluster integration. Detailed physical data models, schema definitions, and implementation-level data governance procedures are intentionally excluded from the scope of this paper and are considered part of subsequent solution design and implementation phases.

The target data architecture defines core data entities for each service cluster and how they relate to shared master data across SPJM. For Marine Service, core entities include service order, vessel, voyage, service operation, and tariff. In the Crewing cluster, key entities include crew member, qualification, assignment, and training record. Port & Equipment relies on asset, maintenance plan, work order, and telemetry data. Dredging & Shipyard requires project, contract, progress, and cost entities, while Utilities uses service point, meter, consumption, and invoice entities. These core entities are governed through master data management (MDM) principles so that a single source of truth is maintained and can be shared across clusters and with Pelindo's holding-level systems [6], [8], [22].

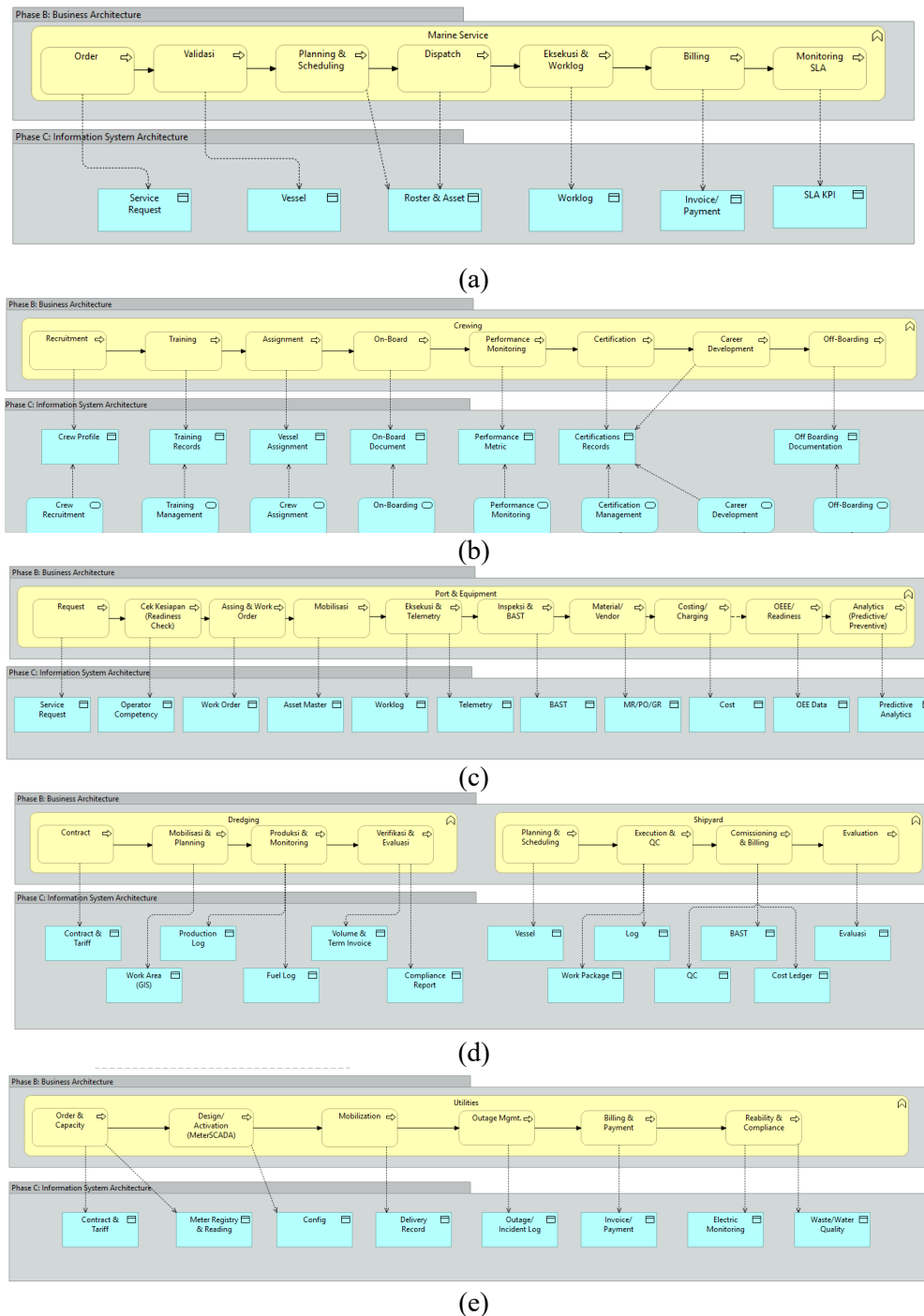
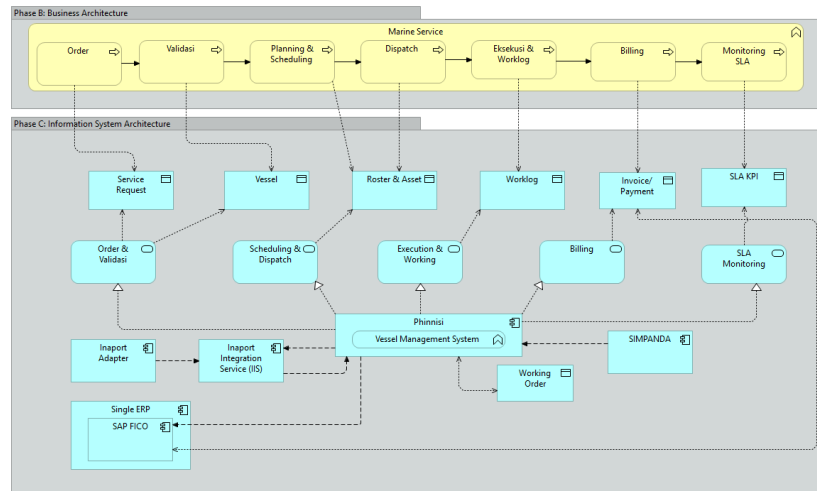


Figure 3. Data Architecture,  
(a) Marine, (b) Crewing, (c) Port & Equipment Service, (d) Dredging & Shipyard, (e) Utilities

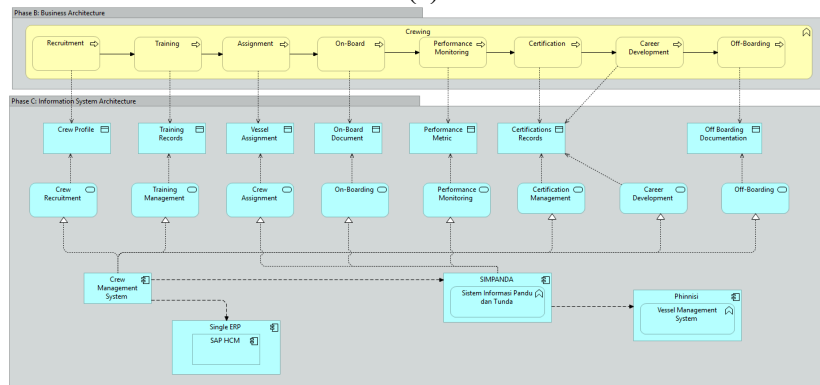
### 3.4. Application Architecture

The application architecture follows a "one core application per cluster" principle. Each service cluster is supported by a core system of record that manages its main processes and data. For example, an integrated marine service management system handles order-to-cash processes for marine operations, while a crewing management system supports crew lifecycle management. Around these core systems, satellite applications are used for specialised functions such as mobile field execution, analytics dashboards, or integration with external partners. All core and satellite

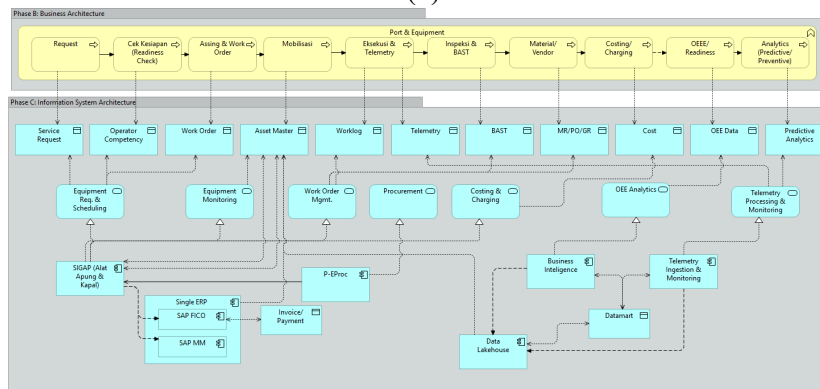
applications are integrated through an enterprise service bus (ESB) or API management platform to enable real-time data exchange and process orchestration [7], [13], [23].



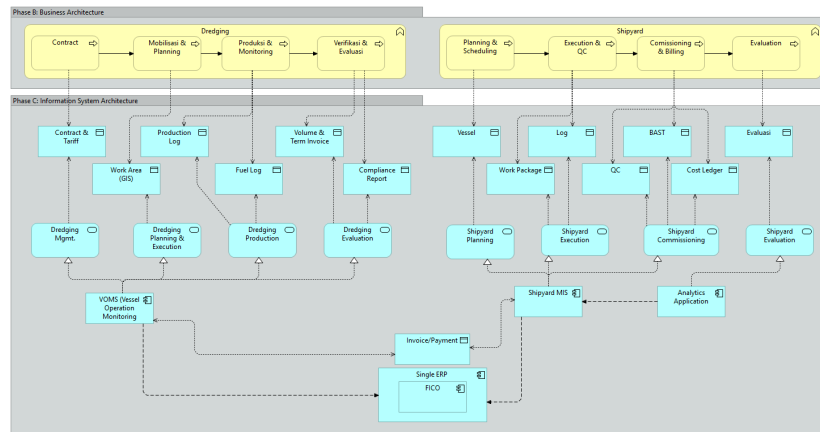
(a)



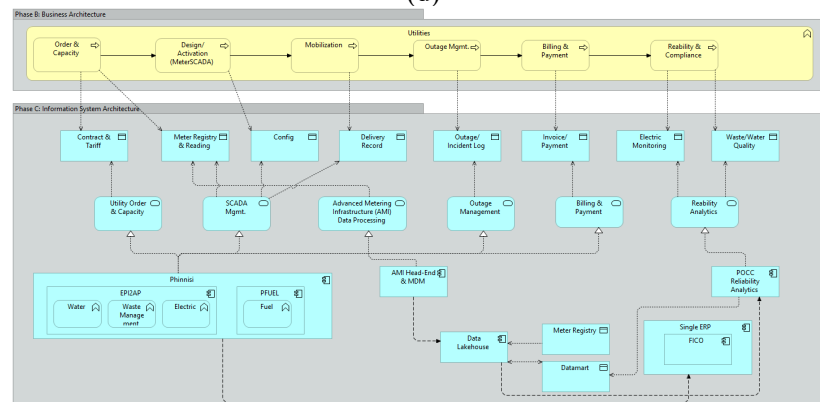
(b)



(c)



(d)



(e)

Figure 4. Application Architecture,

(a) Marine, (b) Crewing, (c) Port &amp; Equipment Service, (d) Dredging &amp; Shipyard, (e) Utilities

### 3.5. Technology Architecture

The technology architecture adopts a hybrid approach that combines private cloud, public cloud, and on-premise infrastructure, taking into account regulatory requirements, latency constraints, and existing investments. Common platform services include identity and access management, monitoring, logging, and security services that are shared across clusters. For Port & Equipment and Utilities, the architecture integrates Industrial Control Systems (ICS), IoT sensors, and SCADA platforms to collect real-time data from cranes, tugs, dredgers, and utility networks. Network segmentation and security controls are designed to protect operational technology (OT) environments while still enabling data sharing with IT systems for analytics and decision support [1], [4], [18], [19], [24], [25], [26].

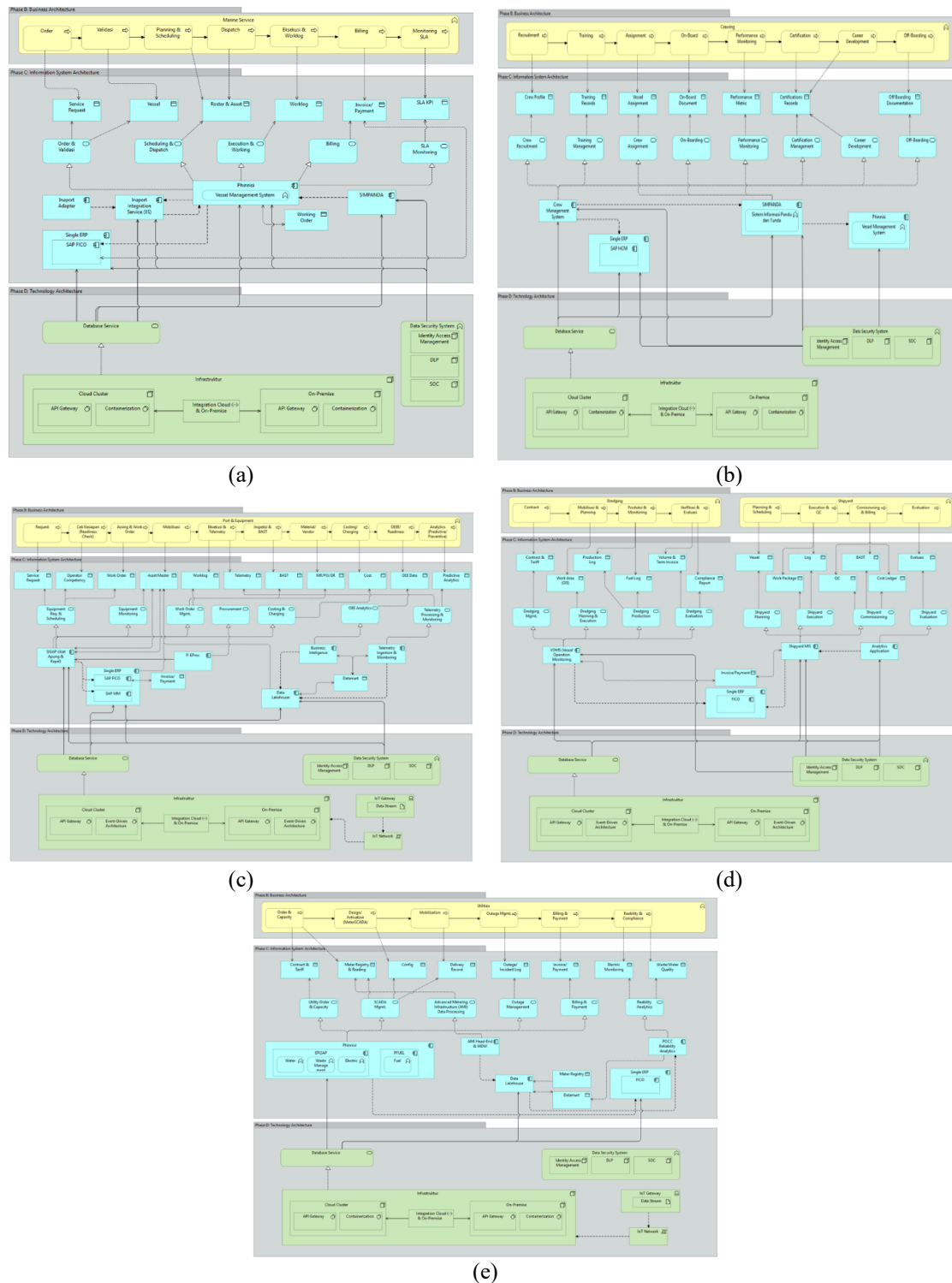


Figure 5. Technology Architecture,  
(a) Marine, (b) Crewing, (c) Port & Equipment, (d) Dredging & Shipyard, (e) Utilities

### 3.6. Alignment and Expected Benefits

The proposed EA is aligned with Pelindo's group-level principles on standardisation, interoperability, and cybersecurity. By consolidating fragmented applications into standardised core systems and defining shared data entities, the architecture is expected to reduce duplication, simplify integration, and improve data quality. The hybrid technology platform enables SPJM to gradually modernise its legacy systems while supporting new digital services such as smart-port analytics and customer self-service portals. In the long term, the EA blueprint can guide investment

priorities and serve as a basis for more detailed solution architectures and implementation roadmaps [6], [7], [9], [21], [27], [28], [29]. Nevertheless, the proposed standardisation introduces trade-offs between enterprise-wide consistency and cluster-specific flexibility, which require careful governance during implementation.

#### 4. CONCLUSION

This study developed an enterprise architecture (EA) for PT Pelindo Jasa Maritim (SPJM) using the TOGAF Standard, ensuring consistency with the company's strategic direction as articulated in the RJPP and the IT Masterplan. The resulting blueprint spans the business, data, application, and technology domains and is structured around five primary service clusters Marine, Crewing, Port & Equipment, Dredging & Shipyard, and Utilities that collectively represent SPJM's maritime services value chain.

Across these domains, the design emphasises end-to-end standardisation of core processes, the definition of cross-entity master data to strengthen enterprise-wide data governance, and an application landscape that supports consolidation and integration. In particular, the proposed target state applies a clear principle of one primary application per service cluster, complemented by a core-and-satellite pattern to enable interoperability and to support integrated Marine–Equipment–Port–Services (MEPS) operations.

From a technology perspective, the architecture proposes a secure hybrid-cloud platform that combines cloud and on-premise capabilities, enabled through an API gateway and reinforced by baseline security mechanisms such as identity and access management (IAM), security operations (SOC), and data loss prevention (DLP). The design also incorporates IoT adoption for the Port & Equipment and Utilities clusters through telemetry and integration with monitoring tools, bridging operational and information technologies where required. Overall, the proposed EA provides SPJM with a coherent reference architecture to guide digital transformation, improve process and application standardisation, and translate strategic requirements into implementable architectural building blocks, while also supporting alignment with holding-level initiatives and smart port directions.

Nevertheless, the scope of this work is intentionally concentrated on core processes, core applications, core data entities, and the major enabling technology components per service cluster. As a result, it does not exhaustively capture all supporting systems or the full variability of operational procedures within each cluster. Future work can build on this foundation by defining quantitative EA evaluation metrics, detailing an implementation roadmap with sequencing and governance mechanisms, and conducting longitudinal assessments to measure realised organisational benefits after rollout [30].

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