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# Analysis of the Implementation of the ORBIT System in Supporting Ship-to-Ship (STS) Cargo Handling Operations

Jonathan Hosea Melato*, Benny Agus Setiono and Carlos Lazaro Prawirosastro
Hang Tuah University, Surabaya, Indonesia
*jonathanhoseamelato@gmail.com

**Abstract**

Ship-to-ship (STS) coal transshipment operations in Muara Berau waters require timely, accurate, and traceable operational reporting to ensure effective coordination and documentation. PT Pelabuhan Tiga Bersaudara utilizes the Online Real-time Integrated Tracking (ORBIT) system to integrate operational data and documentation, from shipper registration to electronic billing (E-Billing). This study aims to analyze ORBIT implementation procedures, identify technical, operational, and human resource-related challenges, and evaluate contingency measures during system disruptions. A descriptive-analytical qualitative approach was employed during an onshore internship conducted from August 2025 to February 2026. Data were collected through direct observations, semi-structured interviews with the Port Captain, Stevedoring Supervisor, and Radio Operator, and documentation reviews covering Booking Orders, Verification Reports, Statements of Facts, Time Sheets, and screenshots of system disruptions. Data analysis involved data reduction, data presentation, conclusion drawing, and triangulation across sources and collection techniques. The findings indicate that ORBIT has facilitated the digital integration of STS operational workflows and improved document processing efficiency under stable network conditions. However, real-time reporting remains constrained by weather-related communication dead zones, dependence on a web-cloud architecture, the absence of automated input validation mechanisms, and operator-related data entry errors. Contingency procedures involving WhatsApp, Microsoft Excel, and manual Time Sheets enable cargo loading operations to continue during system outages but introduce duplicate data entry requirements for shore-based administrative personnel. The findings highlight the need for an offline-first system architecture, automated input validation, improved maritime communication infrastructure, and targeted operator training. These improvements are expected to minimize duplicate data entry, enhance data consistency, and strengthen the continuity and reliability of operational reporting in STS coal transshipment activities.

**Keywords:** ORBIT System, Ship-to-Ship (STS) Operations, Communication Dead Zones, Contingency Procedures, Data Reliability.

## 1. INTRODUCTION

Shipping and port industries play a strategic role in global logistics systems by facilitating the movement of vessels, cargo, documentation, and port-related services. The ongoing digital transformation of the maritime sector has encouraged port operators to replace fragmented administrative processes with integrated digital platforms. Digitalization can enhance transparency, traceability, and decision-making efficiency; however, its effectiveness depends on technological readiness, organizational processes, and user capabilities [1]. The adoption of digital systems in port operations is frequently constrained by interoperability challenges, data quality issues, limited user competencies, and inadequate communication infrastructure [2], [11].

Muara Berau waters, located in East Kalimantan, Indonesia, constitute a major coal transshipment area where ship-to-ship (STS) operations are widely implemented. Coal cargo is transferred from barges to mother vessels using floating cranes or floating loading facilities. In offshore operations, productivity is determined not only by the technical capabilities of cargo-handling equipment but also by the efficiency of

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coordination among shippers, stevedoring companies, shipping agents, surveyors, Port Business Entities (Badan Usaha Pelabuhan, BUP), and port authorities. Vessel service time and turnaround time are important performance indicators in port management [3]. Previous studies on STS operations have emphasized that communication, operational supervision, stowage planning, weather conditions, equipment readiness, and procedural compliance significantly influence operational efficiency [4], [5].

PT Pelabuhan Tiga Bersaudara Samarinda utilizes the Online Real-time Integrated Tracking (ORBIT) system as a centralized platform for administering and monitoring STS operations in the Muara Berau area. The system manages shipper registration, Booking Orders, document verification, stevedoring company and floating crane assignments, Work Order issuance, cargo-loading progress updates, final verification, and electronic billing (E-Billing). This integration reflects the growing demand for information system-based vessel service management. A previous study on the implementation of Inaportnet in Samarinda demonstrated that the effectiveness of digital port services is also influenced by user familiarization and the technical reliability of the system [6].

Digitalization in port services generally exhibits two important characteristics. First, integrated platforms can streamline document exchange and improve information traceability. Second, the realization of these benefits depends heavily on system interoperability, data quality, user competencies, and the reliability of communication infrastructure [1], [2]. In the context of Inaportnet implementation at the Port of Samarinda, technical reliability and user familiarization have also been identified as important determinants of vessel service effectiveness [6]. Unlike conventional land-based port services, ORBIT operates within offshore STS environments, where system performance is additionally influenced by satellite connectivity, weather conditions, and the movement of floating facilities. These operational differences highlight the importance of further investigation, as digital systems that perform effectively in conventional port environments may not demonstrate comparable reliability under offshore operating conditions.

The offshore operating environment presents challenges that differ considerably from those encountered in shore-based offices or port terminals. Access to ORBIT depends on satellite and internet connectivity, making reporting reliability sensitive to weather conditions, the positioning of floating facilities, and signal reception quality. Preliminary observations conducted during the onshore internship revealed login failures, system freezing, and connection interruptions during heavy rainfall and strong winds. Reporting disruptions occurred approximately four to six times per month, while data synchronization delays ranged from approximately two to five hours. These conditions undermine the real-time functionality of the system and necessitate contingency procedures to prevent interruptions to offshore cargo-handling operations.

Another significant challenge concerns data entry accuracy. The existing system does not incorporate automated validation mechanisms capable of rejecting cargo tonnage values that fall outside reasonable operational limits. Typographical errors, operator fatigue, and inconsistent interpretations of operating procedures may result in data discrepancies requiring additional verification. When ORBIT becomes inaccessible, operational personnel rely on WhatsApp for communication, locally stored Microsoft Excel files for data recording, and manual Time Sheets for documenting cargo-handling activities. Although these contingency measures maintain operational continuity, they require administrative personnel to re-enter the recorded information once network connectivity is restored.

Previous studies on coal transshipment have primarily focused on optimizing floating crane allocation or addressing physical and operational constraints associated with cargo-handling activities [4], [7]. Meanwhile, research on port information systems has largely concentrated on publicly operated digital platforms, such as Inaportnet [6]. Limited attention has been devoted to privately operated Port Business Entity information systems that integrate STS documentation, offshore connectivity challenges, and the operational trade-offs associated with contingency procedures. Accordingly, this study aims to analyze the operational workflow of the ORBIT system, identify factors affecting the reliability of operational reporting, and formulate optimization strategies for coal STS operations in Muara Berau waters.

## 2. METHODS

### 2.1. Research Object and Location

This study employed a descriptive-analytical qualitative approach to investigate the implementation of the ORBIT system and examine the relationship between digital administrative procedures and actual

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offshore operating conditions. A qualitative approach was considered appropriate because the research required an in-depth understanding of personnel experiences, operational decision-making, communication network limitations, and coordination mechanisms during system disruptions [8].

The research was conducted at PT Pelabuhan Tiga Bersaudara Samarinda and its STS operational area in Muara Berau waters from August 4, 2025, to February 5, 2026. The investigation primarily focused on the Stevedoring and Ship-to-Ship Division, which is directly responsible for coordinating cargo-handling activities and managing operational reporting through ORBIT.

### 2.2. Data Sources and Collection

Research informants were selected using purposive sampling based on their direct involvement in ORBIT operations. The selected informants comprised the Port Captain for Stevedoring Operations, the Stevedoring Supervisor, and the STS/Tally Radio Operator. These positions were selected because they represent distinct operational responsibilities within the ORBIT workflow. The Port Captain is responsible for operational supervision and decision-making, the Stevedoring Supervisor oversees administrative and operational coordination, and the STS/Tally Radio Operator manages data entry and reporting directly from the offshore transshipment location. This selection enabled comparisons across different organizational levels involved in both digital administration and field operations.

Primary data were obtained through non-participant observations and semi-structured interviews. Secondary data consisted of Booking Orders, Verification Reports (Laporan Hasil Verifikasi, LHV), Work Orders (Surat Perintah Kerja, SPK), Statements of Facts, Time Sheets, cargo-loading progress reports, backup Excel files, WhatsApp coordination records, and screenshots documenting system access disruptions. The distinction between primary and secondary data was maintained to ensure that operational statements could be cross-checked against relevant documentary evidence [9].

### 2.3. Data Analysis and Trustworthiness

Data analysis was conducted through three main stages: data reduction, data presentation, and conclusion drawing. Interview transcripts and field observation notes were categorized into three principal themes: operational procedures, technical and operational challenges including human resource factors, and emergency mitigation mechanisms.

The thematic findings were subsequently compared with operational documents and field observations to develop a gap analysis and identify the underlying causes of system performance limitations. The trustworthiness of the findings was assessed through source triangulation by comparing responses from the three informants and methodological triangulation by examining the consistency of information obtained through interviews, observations, and company documentation [10].

In practice, triangulation was conducted separately for each research theme. Statements provided by the Port Captain, Stevedoring Supervisor, and Radio Operator were initially compared to identify similarities and differences in their operational experiences. These findings were then cross validated against observation records and supporting documents, including Booking Orders, Verification Reports (LHV), Work Orders (SPK), Time Sheets, backup Excel files, and screenshots of system disruptions. This process was intended to assess the consistency between informant accounts and documented operational conditions, thereby strengthening the credibility of the research findings.

## 3. RESULTS AND DISCUSSION

### 3.1. Operational Workflow of the ORBIT System

The findings indicate that ORBIT serves as the primary digital platform for managing STS services at PT Pelabuhan Tiga Bersaudara. The operational process begins with shipper account registration and the submission of required legal and administrative documents. Following document verification, the shipper submits a Booking Order containing vessel identification details, cargo information, the proposed operational schedule, and service requirements. PT Pelabuhan Tiga Bersaudara subsequently examines completeness document, coordinates the Cargo Loading and Unloading Activity Plan (Rencana Kegiatan Bongkar Muat, RKBM) through Inaportnet, assigns the stevedoring company and floating crane, and

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verifies the submitted information against the surveyor's Verification Report (LHV).

Once all administrative and operational requirements have been satisfied, a Work Order (SPK) is issued as the formal authorization for cargo-loading activities. During STS operations, the Radio Operator records cargo tonnage progress and other operational information directly from the offshore location, while the Stevedoring Supervisor and Port Captain monitor operational compliance and ensure consistency between reported activities and actual field conditions.

Upon completion of cargo loading, initial and final draft surveys are used to verify the total quantity of cargo transferred. The validated operational data subsequently provide the basis for preparing the Statement of Facts, proforma invoice, and E-Billing documentation. Under stable network conditions, this integrated digital workflow can reduce document processing times from approximately 12–24 hours to only a few minutes, as relevant documents are centrally accessible and can be reviewed by authorized stakeholders within a single platform.

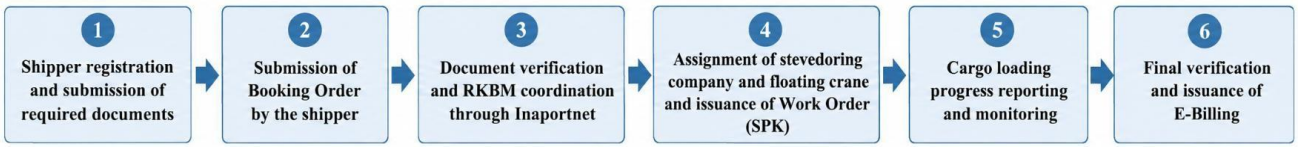



Figure 1. Operational Workflow of the ORBIT System in Ship-to-Ship Operations at Muara Berau.

### 3.2. Key Findings and Data Triangulation

Three major themes emerged from interviews, field observations, and document reviews. First, all informants confirmed that STS service procedures had transitioned from conventional administrative processes to an integrated digital system. Second, all informants identified adverse weather conditions and network instability as the primary constraints affecting system accessibility in offshore operational areas. Third, the three informants described the implementation of contingency mechanisms involving WhatsApp, Microsoft Excel, and physical documentation when ORBIT became inaccessible. These findings were cross validated using observational records and operational documents to assess the consistency of information obtained from different sources. A summary of the triangulation results is presented in Table 1.

Table 1. Matrix of Key Findings and Data Triangulation

| Theme | Interview Findings | Observations and Documentary Evidence | Triangulation Conclusions |
|---|---|---|---|
| Digitalization of operational procedures | ORBIT is used for Booking Orders, document verification, Work Orders (SPK), cargo progress reporting, and billing. | Booking Orders, Verification Reports (LHV), Work Orders (SPK), and E-Billing documents are integrated into the system workflow. | STS services have transitioned toward an integrated digital operational environment. |
| Network vulnerability | Adverse weather conditions may cause login failures, system freezing, and delayed data updates. | System error screenshots and delayed transmission of cargo progress reports from offshore locations. | The online system architecture remains dependent on stable offshore network connectivity. |
| Emergency contingency measures | Work Orders and operational reports are transmitted through WhatsApp, while local data are recorded using excel and time sheets | Operators print documents onboard, while shore-based administrative personnel re-enter data after network connectivity is restored. | Operational continuity is maintained, but additional administrative workloads and risks of repeated data entry errors arise. |

### 3.3. System Reliability Constraints and Gap Analysis

The most significant technical constraint identified in this study was network instability during adverse weather conditions. Although the company has deployed two Starlink terminals in the offshore operational area, connectivity may still deteriorate during heavy rainfall, strong winds, and movements of floating

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facilities. Since ORBIT operates as a web-based cloud application without local data storage capabilities, operators cannot continue entering operational data when network connectivity is interrupted. Consequently, data updates can only be completed after the connection is restored, meaning that the dashboard at the company's headquarters may not consistently reflect actual offshore operating conditions.

Another important limitation concerns data entry accuracy. Although the company's Standard Operating Procedures (SOPs) establish a zero-discrepancy target, the existing application does not incorporate an automated validation mechanism, referred to in this study as a Validation Guard, to restrict unreasonable cargo tonnage values, enforce numerical input formats, or detect duplicate entries. Consequently, supervisors must manually verify operational records whenever inconsistent or implausible values are identified. From a human resource perspective, some operators have acquired system-related competencies through independent learning rather than standardized formal training. The likelihood of human error may increase when operators experience fatigue or are required to manage multiple operational documents simultaneously [12], [13], [14].

Table 2. Gap Analysis of ORBIT System Implementation

| No. | Indicator | Expected Performance | Actual Conditions | Identified Gap | Operational Implications |
|---|---|---|---|---|---|
| 1 | System accessibility | Continuous real-time access (24 hours) | Communication dead zones during adverse weather | Unstable network connectivity | Data updates delayed by approximately 2–5 hours |
| 2 | System architecture | Automatic data synchronization | Web-based online application without an offline module | Absence of offline functionality | Data entry is interrupted during connection failures |
| 3 | Data accuracy | Zero data discrepancies | Incorrect cargo tonnage entries still occur | Absence of automated input validation (Validation Guard) | Additional manual verification and risk of data discrepancies |
| 4 | Human resource capacity | Competent and adequately trained operators | Inconsistent operator training and self-directed learning | Differences in operational competencies | Increased susceptibility to data entry errors under fatigue |
| 5 | Contingency procedures | Seamless operational fallback | Manual reporting through WhatsApp and Excel | Redundant administrative procedures | Duplicate data entry requirements for shore-based personnel |

The root cause analysis identified four interrelated categories of contributing factors. The first category concerns technological limitations, particularly the system's dependence on satellite connectivity and the absence of an offline-first architecture and automated input validation. The second category involves human factors, including differences in digital literacy, inadequate standardized training, and operator fatigue, which may affect data entry accuracy. The third category relates to operational procedures, particularly the lack of integration between contingency reporting mechanisms and the primary ORBIT platform, resulting in duplicate data recording. The fourth category comprises environmental factors, including weather conditions, wave activity, offshore location, and floating facility movements, which influence communication signal reception. The interaction among these factors contributes to communication dead zones, reporting delays, and inconsistencies in operational data.

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Figure 2. Root Cause Analysis of ORBIT System Disruptions and Data Discrepancies.

Within the broader framework of digital transformation, ORBIT represents a transition from fragmented administrative procedures toward integrated process and data management through a centralized platform. However, digital transformation extends beyond the conversion of manual documentation into electronic formats. Sustainable operational benefits can only be achieved when technological infrastructure, organizational processes, and user capabilities function consistently and effectively [1]. The findings of this study support this perspective, demonstrating that the web-cloud architecture enhances information traceability under normal network conditions but loses its real-time reporting capability when offshore connectivity is interrupted.

From an information system reliability perspective, three operational dimensions are particularly important: system accessibility, data accuracy, and process continuity. Communication dead zones reduce system availability, the absence of automated input validation increases the likelihood of inaccurate operational records, and manual contingency procedures preserve operational continuity at the expense of additional data entry requirements. These findings are consistent with previous research identifying data quality, user competencies, and communication infrastructure as major challenges in port digitalization [2]. They also align with studies of Inaportnet implementation, which emphasize the importance of technical reliability and user readiness in determining the effectiveness of digital port services [6].

### 3.4. Emergency Contingency Measures and Optimization Strategies

When ORBIT becomes inaccessible, operational personnel implement established contingency procedures to maintain STS activities. Vessel information and cargo-loading progress are recorded using manual Time Sheets or locally stored Excel files. Shore-based administrative personnel transmit Work Orders (SPK) through WhatsApp, after which the Radio Operator prints the documents and submits them to the Port Captain to authorize the continuation of loading operations. Cargo tonnage reports and photographs of supporting documents are also exchanged through designated communication groups. These procedures are intended to prevent interruptions to offshore cargo-handling equipment operations, thereby supporting operational continuity and maintaining STS productivity despite temporary digital system failures.

Although these contingency measures are effective in maintaining operational continuity, they introduce several operational trade-offs. Once network connectivity is restored, administrative personnel must retrieve information from Time Sheets or WhatsApp messages and manually re-enter the corresponding data into ORBIT. This duplicate data entry process increases administrative workloads, prolongs document processing, and introduces additional opportunities for human error. Furthermore, the use of multiple communication channels may generate inconsistencies between different versions of operational records when standardized timestamps, authorization procedures, and data reconciliation mechanisms are not adequately implemented.

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Table 3. Optimization Priorities for the ORBIT System

| Priority | Identified Problem | Proposed Improvement | Expected Outcome |
|---|---|---|---|
| 1 | Dependence on continuous network connectivity | Implement an offline-first architecture incorporating local data storage, synchronization queues, and automatic synchronization. | Continuous data entry during network disruptions and reduced duplicate data entry. |
| 2 | Data entry errors | Introduce automated input validation (Validation Guard), reasonable value thresholds, mandatory input formats, and duplicate-entry alerts. | Improved data accuracy and reduced manual verification requirements. |
| 3 | Offshore communication dead zones | Improve antenna systems, evaluate marine signal boosters, monitor network quality, and establish alternative communication channels. | Improved system accessibility and faster data synchronization. |
| 4 | Differences in operator competencies | Conduct regular training, system disruption simulations, practical user guidance, and periodic operator evaluations. | More consistent operational responses and reduced risks of human error. |

The implementation of an offline-first architecture is identified as the primary optimization recommendation because it directly addresses the connectivity limitations inherent in offshore operations. Under this approach, operational data can be entered and stored locally on user devices, assigned timestamps, and placed in a synchronization queue. Once network connectivity is restored, the system can automatically transmit the stored information to the central database while applying mechanisms to prevent duplicate records and resolve potential version conflicts. Automated input validation should be implemented alongside this architecture to ensure that improvements in system availability are accompanied by enhanced data accuracy. Upgrades to communication infrastructure and regular operator training would provide additional layers of support for improving overall system reliability [15].

The optimization priorities presented in Table 3 should be distinguished from the technical sequence required for their implementation. Although offline-first architecture remains the highest strategic priority because it addresses the underlying dependence on continuous network connectivity, its development requires substantial modifications to the existing system architecture. These modifications include local data storage, synchronization mechanisms, version conflict management, data security controls, and comprehensive system testing.

Accordingly, the initial implementation phase should focus on improvements that can be introduced relatively quickly, including automated input validation, standardization of contingency SOPs, operator training, and continuous network quality monitoring. These measures can be implemented in parallel to strengthen existing operational controls while more extensive system modifications are being prepared.

The subsequent phase should prioritize communication infrastructure improvements through systematic evaluation of antenna positioning, the suitability of marine signal boosters, and the availability of alternative communication channels. Finally, the first offline architecture should be developed as the principal long-term system enhancement once data synchronization procedures, security requirements, and duplicate-entry prevention mechanisms have been adequately validated. This phased implementation strategy would enable the company to achieve short-term operational improvements while progressively establishing a more reliable and sustainable digital architecture for offshore STS operations.

### 3.5. Practical Implications

For PT Pelabuhan Tiga Bersaudara, the findings of this study provide a systematic basis for prioritizing improvements to the ORBIT system by identifying the primary sources of operational disruptions encountered during ship-to-ship (STS) activities. The proposed implementation of an offline-first architecture, combined with enhanced maritime communication infrastructure, is expected to reduce data synchronization delays and minimize the need for manual data re-entry. Meanwhile, the integration of an automated input validation mechanism (Validation Guard) would strengthen data accuracy before operational records are used for verification and billing purposes. Accordingly, the anticipated benefits extend beyond improvements in administrative efficiency to include greater process traceability, enhanced

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information consistency, and more reliable data exchange among stakeholders involved in STS operations.

For offshore operational personnel, standardized contingency procedures, clear data entry guidelines, automated validation mechanisms, and regular training programs could reduce the burden of manual verification and minimize inconsistencies in operational practices during system disruptions. For information system administrators and developers, the gap analysis and root cause assessment provide a basis for translating operational challenges into specific technical requirements, including local data storage, synchronization queues, duplicate-entry prevention, network connectivity monitoring, timestamp logging, user authorization, and data reconciliation mechanisms. The effectiveness of these improvements could subsequently be evaluated using measurable operational indicators, such as delay duration, frequency of duplicate data entry, number of data discrepancies, and document processing time. Monitoring these indicators would enable the company to assess the operational impact of system enhancements consistently and support evidence-based decisions regarding future digital infrastructure development.

## 4. CONCLUSIONS

This study demonstrates that the Online Real-time Integrated Tracking (ORBIT) system has facilitated the digitalization and integration of ship-to-ship (STS) operational procedures at PT Pelabuhan Tiga Bersaudara, encompassing shipper registration, Booking Order submission, Verification Report (LHV) validation, Work Order (SPK) issuance, cargo-loading progress updates, final draft surveys, Statement of Facts preparation, and electronic billing (E-Billing). The integration of these administrative and operational processes has improved document exchange efficiency and strengthened data traceability under stable network conditions. However, the system's real-time reporting capability remains constrained by communication dead zones during adverse weather conditions, dependence on a web-based cloud architecture, the absence of automated input validation mechanisms, and the potential for operator-related human errors. These findings indicate that digital integration alone is insufficient to ensure operational reliability in offshore environments without adequate connectivity, data quality controls, and supporting organizational procedures.

Contingency measures involving WhatsApp, Microsoft Excel, and manual Time Sheets have enabled cargo-loading activities to continue during system disruptions. Nevertheless, these procedures introduce duplicate data entry requirements and increase the risk of inconsistencies between operational records. Therefore, ORBIT optimization should prioritize the development of an offline-first architecture, automated input validation, improved maritime communication infrastructure, and systematic operator training. The implementation of these improvements should be supported by standardized contingency procedures, clearly defined personnel responsibilities, timestamp recording, and data reconciliation mechanisms to ensure that operational continuity and information reliability are maintained simultaneously. A phased implementation strategy is recommended, combining short-term improvements such as input validation, contingency procedure standardization, operator training, and network monitoring with the progressive development of an offline-first architecture as the principal long-term solution. These recommendations provide a practical foundation for strengthening the resilience, accuracy, and sustainability of digital reporting systems supporting offshore coal transshipment operations.

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