

Digitalisation in Freight Forwarding for Service Differentiation

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Abbreviations

Abbreviation	Meaning
FF	Freight Forwarder
BC	Blockchain
IoT	Internet of Things
AI	Artificial Intelligence
ABS	Azure Blob Storage
AF	Azure Functions
ERP	Enterprise Resource Planning
MBL	Master Bill of Lading
HBL	House Bill of Lading
B/L	Bill of Lading
POL	Port of Loading
POD	Port of Discharge
JIT	Just-In-Time
VPN	Virtual Private Network
NLP	Natural Language Processing
JSON	JavaScript Object Notation
IDS	Intrusion Detection System
RBAC	Role-Based Access Control
EDR	Endpoint Detection and Response
HSM	Hardware Security Module
MITM	Man-In-The-Middle
TLS	Transport Layer Security

Technical Report: Digitalisation in Freight Forwarding for Service Differentiation

Introduction

Maritime transportation accounts for over 90% of global trade and operates through a fragmented supply chain involving a wide range of actors beyond exporters and importers, such as freight forwarders (FFs), carriers, and NVOCCs. Despite its central role in global commerce, the sector continues to face persistent challenges, including inefficiency, fraud, and lack of transparency (Irannezhad and Faroqi, 2021).

Strategic Context

The FF segment in Türkiye is experiencing intense competition, primarily driven by the horizontal and vertical integration strategies of global shipping lines (CMA CGM, 2018; Maersk, 2022b), as well as the increasing number of local and global FFs. Although my company maintains its market position in a very fragmented market, these pressures have significantly eroded profit margins, prompting the company to focus on client-based service differentiation as a key strategic response. Consequently, delivering tailored, faster, efficient solutions that are difficult to replicate has become a top strategic priority for the company.

Use case of interest

Digitalisation is increasingly recognised as a key driver for enhancing customer value and securing competitive advantage in this environment (Dagar, Tate, and Johnstone, 2024). Although many carriers have partially initiated Blockchain (BC) B/L (Haupt, 2021; Maersk, 2025), through WaveBL (Wave BL, accessed 30.06.2025) platform, there is no example of a FF in Türkiye implementing the technology due to lack of investment initiatives and the currently low use of BC in the supply chain (Green et al., 2020). Legal regulation constraints, security issues, and interoperability between platforms issues have been considered and mitigated during the project (Nguyen, Chen and Du, 2020)

Nevertheless, the company has already adopted cloud technologies and maintains high security standards, operates with international ERP systems, such as SAP, and has strategic partnerships with international IT software providers, e.g., Microsoft. It therefore has an infrastructure that would facilitate emerging technology applications.

This report examines a pilot digitalisation initiative within the *FF export division* of my company, which accounts for approximately 50% of its total turnover. The aim is to evaluate the benefits and risks of adopting the chosen emerging digital technologies, assessing their potential to create competitive advantage through differentiated services and enhanced client service quality.

Among emerging technologies, *Blockchain (BC)* offers decentralised, tamper-resistant data handling and secure document exchange, effectively addressing critical challenges such as delays and errors in document processing, lack of container traceability, fraud

risks, limited auditability, and inefficiencies across the end-to-end shipment lifecycle (Mourouzis, 2020). Furthermore, its ability to integrate with other technologies—such as the *Internet of Things (IoT)*, *Artificial Intelligence (AI)*, and *Cloud Computing Services*—enhances tracking analysis, better visibility, allowing to optimise routes, predict future demand, create seamless data exchange and enables end-to-end process automation (Arnob, 2025; Stylianos Kampakis et al., 2022) across stakeholders for better customer experience. Hence, these four technologies have been selected for the project, with BC serving as the core infrastructure.

Challenges without digital transformation of the use case

The end-to-end process—beginning with booking, followed by container stuffing, vessel loading, documentation, voyage tracking, document surrender, and final delivery to the consignee—is highly complex. In the traditional model, most documents are manually entered into the company’s ERP system, verified, and distributed via email to relevant stakeholders. This workflow introduces multiple inefficiencies and risks, each of which may adversely affect client relationships to varying degrees.

1. Lack of real-time container visibility: Reduces service quality (Abogro and Korang, 2025)
2. Complex manual process of issuing, verifying paper documents: Increased risk of human error and inefficiencies (Mourouzis, 2020).
3. Slow B/L transmission: Delayed cargo clearance and elevated risk of storage and demurrage charges (Anh, 2019).
4. High processing cost: Excessive operational and overhead costs and reduced profitability. (Administrative costs account for 37% of the total FF fee) (Irannezhad and Faroqi, 2021).
5. Lack of overall transparency in the documentation flow: Limited auditability and control across the shipment workflow (Abogro and Korang, 2025; Mourouzis, 2020)
6. Mismatched data entries, e.g between HBL, MBL, and manifest: Increased likelihood of clearance delays and potential penalties (Irannezhad and Faroqi, 2021).
7. Courier inefficiencies, lost documents: Late document dispatch or courier loss is quite common (internal observation).
8. Document fraud risk: Exposure to legal disputes and operational liabilities (Zhu and Li, 2021).
9. Unstructured data environment: Lack of visibility of trends and missed opportunities for predictive optimisation (Abogro and Korang, 2025; Stylianos Kampakis et al., 2022).
10. Manual invoice calculations: Financial discrepancies and risk of under-recovery.
11. Paper-based archiving only: Risk of data inaccessibility in case of insurance or legal claims (internal observation).

Mitigation of Challenges with Emerging Technologies:

Blockchain CargoX ,(Green et al., 2020; Arnob, 2025)

(2): Automates secure, tamper-proof document transfer via BC smart contract ; **(3-4):** Digitally issues and transfers e-B/Ls instantly (Hampstead, 2018), eliminating courier

loss or delays (Arnob, 2025; CargoX, 2025a) and is legally recognised under the UNCITRAL MLETR framework, enabling electronic transferable records (Vlasic and Cekrljic, 2020; CargoX, 2025b).

(5): Immutable recording of document hashes on blockchain ensures full auditability **(7):** Eliminates physical documents through secure digital delivery **(8):** Uses cryptographic hashing and digital signatures, which are legal in Türkiye (LEXPERA, 2021) to prevent duplication and fraud (CargoX, 2025a; CargoX - Help Centre, 2024); **(11)** Actual documents are encrypted and stored off-chain on IPFS, ensuring privacy and security (Microsoft Learn, 2022)

Blockchain WaveBL is used solely as a platform for FF to obtain the non-negotiable MBL from carriers (Maersk, 2025; Wave BL, 2021) and also to offer the benefits of Cargo X. However, even if there is *no interoperability* (Wave BL, 2024b) between the platforms, the hash can be registered on Cargo X (CargoX Platform Users Manual, Version 3, CargoX, 2021)

IoT (ORBCOMM Sensors)

(1): Provides real-time GPS tracking data, enhancing visibility and reducing delays; **(3-4):** Automation via IoT-triggered smart contracts (Arnob, 2025; Zhu and Li, 2021) reduces administrative overhead; **(9):** Collects structured, real-time container data to improve data-driven decisions (Stylianios Kampakis et al., 2022).

Artificial Intelligence (AI - Azure AI)

(2): Parses emails/documents automatically, reducing human errors. **(6):** Automatically validates and cross-checks documents for consistency. **(9):** Analyses transit time historical data, enabling predictive analytics and proactive route optimisation, e.g., choice of carrier based on transit time analytics. Can find customer trends **(10):** Predictive insights ensure accurate and proactive invoicing based on verified data (Microsoft Learn, 2025; Arnob, 2025)

Cloud Services - Azure Blob Storage (ABS)

ABS can be mapped to all challenges due to its storage function, which is essential for the entire process to function.

(11) Digitally archives documents securely with quick retrieval and legal compliance **(2)** Stores structured outputs after AI parsing for easier document reconciliation **(7)** Provides centralised, secure access to documents without physical handling (Bashir, 2024; Microsoft Learn, 2022)

Mapping of Technologies

Challenge # / Title	Blockchain (CargoX / WaveBL)	IoT (ORBCOMM)	AI (Azure AI)	Cloud (Azure Blob Storage)
1 – Visibility		✔ Real-time GPS tracking (Arnob, 2025)		✔ Stores live data streams and logs

				(Microsoft Learn, 2022)
2 – Manual Documents	✔ Smart contract automation (Green et al., 2020)		✔ Parses unstructured booking instructions (Microsoft Learn, 2025)	✔ Stores structured AI output
3 – Slow B/L Issuance	✔ Instant e-B/L (CargoX, 2025a)			✔ Central B/L storage
4 – Courier Delays / Ops Delay	✔ Digital transfer (Arnob, 2025)	✔ IoT-triggered automation (Zhu & Li, 2021)	✔ AI-driven B/L processing	✔ Removes courier delay via instant access
5 – Auditability	✔ Immutable hashes (CargoX, 2025b)			✔ Version-controlled backups (Bashir, 2024)
6 – Mismatches & Errors	✔ Smart contract validation		✔ AI field verification (Microsoft Learn, 2025)	✔ Secure version history
7 – Paper Dependence	✔ Fully digital delivery (CargoX Help Centre, 2024)			✔ Digital access replaces paper
8 – Fraud Risks	✔ Crypto hashes & signatures (LEXPRA, 2021)			✔ Encrypted, restricted access
9 – Unstructured Data		✔ Structured IoT input (Kampakis et al., 2022)	✔ Parses email content (Arnob, 2025)	✔ Stores predictive & historical data
10 – Manual Invoicing			✔ Predictive invoicing (Microsoft Learn, 2025)	✔ Invoice templates, fast access
11 – Document Archiving	✔ IPFS encrypted storage (Microsoft Learn, 2022)			✔ Secure & compliant archiving (Microsoft Learn, 2022)

Methodology

1- First, the control variables have been decided and they are as follows :

- Defined process scope: a container shipment voyage loading from the client's premises up to the destination port delivery,
- Stakeholder scope: a targeted pilot addressing interoperability and adoption challenges from previous complex BC initiatives (Dagar, Tate, and Johnstone, 2024; Maersk, 2022a; PierNext, 2023), intentionally involving only five core stakeholders: exporter, carrier, POL FF, destination FF agent, and receiver.
- Client selection: Three A+ export clients (~45% of FF division revenue) using only non-negotiable HBLs due to legal restrictions in Türkiye (Esenyel Partners, 2025; Şenol, Özer and Meriç, 2024). Selected for their digital maturity, JIT reliance, and high suitability for predictive analytics and automation (Abogro and Korang, 2025).

2-A process mapping table for traditional workflow processes has been done (see Appendix 1-2

3-A process mapping table for the analysis of traditional and digitised workflows, including assets, variables, and data sources, is presented in Appendix 3.

4. The technology mapping of variables and data sources is derived from Appendix1-2-3 analysis:

Technology-Based Variable Mapping

Technology	Independent Variable (Input)	Data Source	Explanation	Dependent Variable (Outcome)
AI, IoT, CLOUD(ABS)	POL Historical transit time	ORBCOMM	Structured, timestamped data sent by ORBCOMM to AI for predictive analytics of arrival date	AI-predicted time/day of container arrival
AI, ABS	POL Booking instruction variables: sender, received time, cargo details, cargo readiness date, preferred carrier.	Outlook (unstructured email + attachments)	Parsed by AI into structured JSON format. Stored in ABS. Feeds BC -SC	Structured JSON fields such as POL, POD, cargo type, and volume.
AI, ABS	POL B/L instruction variables: sender, cargo details, POL, POD, vessel name	Outlook (unstructured email & attachments)	Parsed by AI to structured JSON to initiate B/L issuance. Feeds BC-SC. Note, these are MBL details. FF can <u>edit</u>	Structured JSON of B/L fields: POL, POD, ETD, cargo details, consignee, Incoterms

			the structured JSON fields before uploading into CargoX to change consignee.	
BC-WaveBL, Cargo X, ABS	POL Carrier payment_status (paid/unpaid)	SAP ERP	ERP confirms payment status. Oracle bridges off-chain data to Cargo X -SC.	Paid
IoT, AI, ABS	POL Cargo loading status (loaded/not loaded)	ORBCOMM	ORBCOMM provides loading date; AI interprets and feeds Cargo X -SC trigger	Loading date
BC-Wave, ABS	POL MBL_issuance_status (issued/not issued)	BC-WaveBL	Carrier digitally issues MBL to FF. Status confirmed via signed WaveBL- BC transaction. Hash can be optionally printed on CargoX.	Issued
BC/CargoX, Oracle, CLOUD(AF, ABS)	POL Client payment_status (paid/unpaid)	SAP ERP, Oracle	Client pays FF. SAP ERP confirms payment to Oracle, which in turn feeds BC-SC.	Paid
BC/CargoX, CLOUD(ABS)	POL HBL_issuance_status (issued/not issued)	CargoX	FF issues HBL. BC records delivery to the client, timestamp, and status	HBL digitally issued
IoT, AI, CLOUD(AF,ABS)	POD Arrival status (arrived/not arrived)	ORBCOMM	ORBCOMM detects arrival and sends structured data to POL FF, AI feeds SC trigger	Arrived

			digitally forward HBL to dest FF. Dest. FF <i>manually</i> informs client via ERP or phone.	
BC- Wave, ABS	POD MBL_surrender_status (surrendered/not surrendered)	Wave	Dest FF digitally surrenders MBL; status recorded on WaveBL ledger. Wave metadata is entered manually to Cargo X.	MBL surrendered
BC-Wave, ABS	POD Carrier delivery_order_issued (issued/ot issued)	Wave	Carrier issues DO via Wave—digitally signed DO. Hash can be printed manually in CargoX.	DO issued
BC-CargoX, ABS	POD HBL_surrender_status	CargoX	POD Client transfers digital ownership of HBL to dest. FF	Surrendered
ERP (Manual – custom not integrated) CargoX is only used as a visibility/logging tool	POD FF delivery_order_issued (delivered / not delivered)	DO with ERP	DO is manually signed and physically delivered to consignee. Dest. FF manually updates status in CargoX.	DO delivered

Digital Assets for Full Integration

Asset	Technology Dependency	Purpose / Function in System
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Azure Blob Storage (ABS)	Cloud Computing	Stores parsed JSON data, booking & B/L info, for traceability & smart contract triggers
Azure Functions (AF)	Cloud Automation	Executes event-based actions like triggering smart contracts or arrival notices
Outlook Email System	Communication Software	Receives client emails for bookings, B/L instructions; feeds AI parser
AI Email Parser	AI + NLP(Pfleeger and Coles-Kemp, 2023,p.901)	Extracts structured fields from unstructured emails and attachments (e.g., POL, POD, cargo)
CargoX Blockchain Platform	Public Blockchain (Ethereum)	Issues, signs, and transfers House B/Ls; logs HBL lifecycle immutably
IoT Sensors (ORBCOMM)	IoT + Predictive Telemetry(ORBCOMM, accessed 9 .07.2025)	Tracks real-time cargo status, feeds location/arrival data into workflow
Laptops/Desktops	End-User Hardware	Used by FF and client-side staff to access ERP, CargoX, WaveBL, email, and cloud systems
Firewall/Router with VPN Access	Network Security	Provides secure, encrypted network tunnels to protect data in transit between forwarder systems (ERP, cloud storage) and blockchain platforms. Prevents eavesdropping, session hijacking, and packet modification during cross-network communication(Pfleeger and Coles-Kemp, 2023,p.400-403)

Risk Assessment – Digital Assets (Cloud, IoT, AI, Blockchain)

Emerging technologies significantly improve efficiency, automation, and visibility across digital supply chains. However, they also introduce complex cybersecurity risks that must be proactively addressed.

Key Risk Themes are

Emerging technologies introduce critical vulnerabilities: **Cloud systems** like Azure Blob can be misconfigured, exposing sensitive data and breaching regulations. **AI models** face risks from evasion or poisoning attacks that distort automated decisions. **Blockchain platforms** such as CargoX rely on secure key management—if compromised, forgery or unauthorised B/L transfers may occur. **IoT sensors** can be spoofed, triggering false delivery signals. **Email systems** like Outlook are prone to phishing, risking credential theft and document tampering. Lastly, **endpoint devices and networks** remain exposed without strong encryption, VPN security, and firewall configuration.

Risk Assessment

Asset	Threat	Vulnerability	C-I-A Impact	Result if Threat Occurs / Vulnerability Exploited	Mitigation
Azure Blob Storage (ABS)	A data breach can occur due to an insider or external attack exploiting misconfigured permissions or a lack of encryption (Pfleeger and Coles-Kemp, 2023, p. 613).	Interfaces and APIs are insecure due to a lack of specific security regulations (Pfleeger and Coles-Kemp, 2023, p.613).	Confidentiality, Integrity	Client data exposure, regulatory breach (e.g., GDPR), loss of client trust.	Implement strict access controls (RBAC), encrypt data at rest and in transit, configure API gateways with authentication, and enable continuous monitoring with Azure Security Centre (Microsoft

					Learn, 2024).
Azure Functions (AF)	Flood or event injection causes system overload, delaying smart contracts or downstream workflows (Pfleeger and Coles-Kemp, 2023, p.402).	No input validation or rate-limiting on triggers.	Availability	Smart contracts or workflows delayed or halted.	Use input validation, apply event throttling and concurrency controls, and implement Azure API Management policies (Microsoft Learn, 2023; Microsoft Learn, 2025a)
Outlook Email System	Phishing leads to credential theft or OAuth token abuse (Pfleeger and Coles-Kemp, 2023, pp. 310–321, 626).	Lack of phishing protection or OAuth awareness training.	Confidentiality, Availability, Integrity	Attacker gains access to email, tampers with or replaces B/L instructions.	Deploy phishing filters, enable S/MIME or Defender for Office 365, restrict OAuth scopes, and train staff regularly (Pfleeger and Coles-Kemp, 2023, p.319–321).
AI (Email Parser)	Evasion attacks or poisoned data mislead model outputs (Pfleeger and Coles-Kemp, 2023, p.904).	AI/NLP models misled during training phase (Pfleeger and Coles-Kemp, 2023, p.904).	Integrity	Mislabeling fields (e.g., wrong consignee, cargo), routing or contract errors.	Adopt adversarial training, audit AI output for anomalies, and implement human-in-the-loop verification

	2023, pp. 904–905).				(Pfleeger and Coles-Kemp, 2023, p.906).
CargoX Blockchain Platform	Digital identity theft via phishing or malware leads to B/L forgery or illegitimate signing (Bashir, 2024, p.632).	Private keys not secured in HSM or encrypted files (Bashir, 2024, p.637).	Integrity	Fake HBL issued or unauthorized transfer occurs.	Use HSMs for key storage, adopt multi-signature controls, and conduct phishing training and key audits.
IoT Sensors (ORBCOMM)	GPS spoofing or sensor manipulation alters cargo status (Pfleeger and Coles-Kemp, 2023, pp. 631–635).	Weak access control and physical exposure of devices.	Confidentiality, Integrity	Container shown as arrived/loaded when it hasn't, triggering early DO or payment.	Encrypt sensor data, physically secure IoT devices, use certificate-based authentication and implement anomaly detection (Pfleeger and Coles-Kemp, 2023, p.635).
Laptops/Desktops	Malware steals private keys from browser-based wallets (Pfleeger and Coles-Kemp, 2023, Ch. 6).	No antivirus or OS isolation; keys stored in browser.	Integrity, Confidentiality	Illegal HBL/MBL issuance or transfer via impersonation.	Use endpoint protection (EDR), secure wallets with TPM or hardware tokens, and isolate browser-based key

					operations (Pfleeger and Coles-Kemp, 2023, Ch. 6).
Firewall/Router with VPN Access	MITM attack due to weak or misconfigured firewall exposes internal VPN and LAN (Bashir, 2024, p.635; Pfleeger and Coles-Kemp, 2023, pp. 405–406, 623–624).	Improper firewall placement, lack of VPN encryption.	Confidentiality, Integrity	Sensitive data intercepted or manipulated; arrival or B/L hash spoofing (Bashir, 2024, p.436).	Ensure strong firewall configuration, use TLS for VPN connections, audit encryption setup, and deploy an IDS for network traffic analysis (Diana, Dini and Paolini, 2025).

Conclusion

This report has demonstrated that digitalisation in freight forwarding—anchored in Blockchain, AI, IoT, and Cloud—offers substantial opportunities for client service differentiation and operational efficiency. By addressing long-standing inefficiencies such as document delays, fraud risks, and data silos, the proposed solution supports faster, more secure, and customer-centric logistics workflows. The company's existing digital infrastructure and strategic positioning make it well-suited to lead this transformation. Going forward, successful implementation will depend on careful risk mitigation, stakeholder alignment, phased implementation and sustained investment in digital capabilities.

APPENDIX 1

All documents are manually prepared in Microsoft Word or Excel documents sent via Outlook through the company's Internet.

Step	Description
0- The client sends a booking request via email. .	Operations staff call the client to confirm, then dispatch the container to the factory for loading. All correspondence is done via e-mail. There is no tracking for the container until arrival of factory and port. Various phone calls are exchanged with the truck driver and client if the container is late which creates customer frustration. Meanwhile....
2. B/L Instruction Form is Sent to Shipper	→ Shipper fills out a B/L information form.
3. Draft HBL Preparation	→ Forwarder prepares draft non-negotiable HBL → Retrieves customs checklist (packing list, weight) → Compares documents for discrepancies
4. Master B/L (MBL) Draft from Carrier	→ If all details match, the forwarder sends the details to the carrier → Carrier drafts MBL (with consignee shown as forwarder) → Real shipper and consignee are hidden
5. HBL/MBL Draft Approval	→ Carrier issues MBL draft → sent to forwarder → Forwarder prepares final HBL draft → sent to shipper for approval
6. Manifest for custom	The manifest is an important document used by countries to monitor taxes, trade, and the economy (Irannezhad and Faroqi, 2021), and is prepared by the forwarder and the carrier for customs purposes. All details must match for smooth operation.
7. Issuance & Distribution	→ HBL set couriered to the shipper → The forwarder collects MBL from the carrier → MBL sent to the destination forwarder agent
8. Arrival of Cargo at the destination	The manifest is presented to the customs and stamped by the authorities at the destination customs.
9. Arrival & Master B/L Surrender	→ Forwarder's agent presents a full set of MBLs to the carrier

	→ Carrier issues the Delivery Order to the forwarder's agent upon receipt of due fees.
10. Final Delivery to Receiver	→ The receiver submits the full HBL set to the forwarder's agent → Forwarder issues Forwarder's Delivery Order upon receipt of due fees. → The receiver presents it to customs/port to collect the cargo
11. Last Custom check	If any discrepancy occurs between the bills of lading and the manifest due to a mistake, the collection of the cargo will be delayed, and storage and demurrage charges will be incurred.

APPENDIX 2

Traditional B/L Process – Assets, Variables, and Data Sources

1. Assets Involved

Category	Asset	Examples / Notes
People	Operations staff at the office and port, client export officers, truck drivers, forwarder agents, customs officers, and carrier documentation teams	Rely on phone and email; communication is manual and often delayed.
Data	Booking request, B/L instructions, commercial invoice, packing list, MBL & HBL drafts, customs manifest, Delivery Order	Stored in Outlook, spreadsheets, and printed copies and later filed.
Hardware	Office computers, printers, scanners, mobile telephones, and courier vehicles.	No real-time container visibility in transit.
Software	Microsoft Outlook, Excel, Word, internal ERP, and Carrier emails.	No real-time integration; mostly manual entry.
Documents	Manually filled and digitally printed HBL, MBL, manifest, and delivery orders sent by courier.	Susceptible to loss, delays, or mismatches across stakeholders.

2. Key Process Variables

Variable	Type	Notes
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booking_received_time	Timestamp	The time the client's booking email is received.
loading_location	Text	Factory or loading point.
container_arrival_status	Boolean	Manually confirmed via phone or portal.
HBL_approval_status	Enum (Pending, Approved)	Tracked by operations through email and phone.
MBL_submission_status	Boolean	Sent or not to the destination forwarder.
customs_clearance_status	Enum (Cleared, Pending, On Hold)	Dependent on document match.
payment_status	Boolean	Confirmed before releasing DO.
delivery_order_issued	Boolean	Triggered once fees are received.

3. Data Sources

Source	Data Origin	Format / Method
Email (Outlook)	Booking notice, B/L instructions	Free text email communication.
Excel / Word Docs	B/L drafts, manifests	Editable documents are exchanged by email.
Phone calls / WhatsApp	Client, Port updates, driver communication.	Unstructured, unlogged confirmations.
Carrier Portal	MBL entry and approval	Web-based form submission.
Courier Service	Hard copy B/L delivery	Paper-based transmission.
Customs Office	Manifest and DO stamping	Manual submission of DO to the client, the manifest is submitted manually to customs.
Internal ERP	Booking and status milestones	Updated manually by operations and archived in paper form for future reference.

APPENDIX 3

Traditional vs Digitalised Blockchain-Based Process – Assets, Variables, and Data Sources

1. Assets Involved

Category	Traditional Process	Blockchain Process
People	Operations staff, client export officers, truck drivers, customs officers, forwarder agents, carrier documentation teams.	Same people company IT/data scientist, IT software developers for interfaces and their equivalents in the Carrier and forwarder agent, IT purchasing staff, smart contract developers with platform credentials, Suppliers of other software. Communication is digital and time-stamped. Users are onboarded into CargoX (client) and WaveBL(frwdr) with digital identities.
Data	Email B/L instructions, Excel forms, customs manifest, paper DOs.	Structured JSON, smart contract logs, Ethereum transaction hashes, container GPS timestamps, tokenised eB/Ls. Data is encrypted, hash-verified, and anchored both on-chain (Ethereum) and off-chain (IPFS/Azure Blob).
Hardware	Office computers, printers, scanners, courier vehicles, mobile phones. No real-time container visibility during transit.	IoT sensors (ORBCOMM), Azure-hosted backend, mobile and laptop terminals. Real-time data feeds trigger smart contracts (e.g., arrival confirmation, invoice release). Courier only for custom.
Software	Outlook, Word/Excel, ERP, carrier emails.	Azure AI and Blob Storage, SAP ERP

		integration, CargoX and WaveBL APIs, Chainlink Oracle to automate decisions based on off-chain data (IoT or email parsing, Ethereum Solidity smart contracts for document and payment automation.
Documents	Printed MBL, HBL, manifest, delivery order (physically couriered).	Digitally signed HBLs and MBLs tokenised as ERC-721 NFTs (CargoX), WaveBL ledger-issued MBLs, smart envelopes, cryptographic DOs. QR-verifiable and timestamped.

2. Key Process Variables

Variable	Traditional	Blockchain
booking_received_time	Timestamped manually via Outlook	Extracted from email and stored via Azure AI to JSON + ERP.
loading_location	Text field in internal docs	Attached to smart contract metadata and audit-traceable.
container_arrival_status	Set manually via call or port terminal email	Automatically updated via ORBCOMM GPS into Azure, which triggers smart contract arrival flag.
arrival_notice_sent	Sent by email or fax	Auto-generated via Azure Function after smart contract receives container status.
HBL_approval_status	Status tracked by email approvals	Set by digital signature (CargoX) using public/private key pair, stored immutably.
MBL_submission_status	Uploaded to carrier portal manually	Signed and transferred via WaveBL API or private blockchain transaction.
customs_clearance_status	Stamped manifest paper physically submitted	Validated by scanning eB/L QR code and matching hash on

		Ethereum or private ledger.
payment_status	Confirmed by finance over email or bank portal	Confirmed via API from SAP ERP and logged in smart contract.
delivery_order_issued	Generated manually after payment check	Triggered autonomously by smart contract after verifying payment and arrival conditions.

3. Data Sources

Source	Traditional	Blockchain
Email (Outlook)	Booking requests and B/L instructions	Azure AI parses email to JSON for smart contract input and ERP sync.
Excel / Word Docs	Used for HBL, manifest drafts	Replaced by ERC-721 HBL token and blockchain-linked metadata.
Phone / WhatsApp	Driver/container updates, unstructured	Sensor-driven IoT data streams into smart contracts for traceable triggers.
Carrier Portal	Manual MBL upload	WaveBL manages MBL via digital issuance, signing, and smart transfer.
Courier	Delivers paper HBLs, manifests	Replaced by CargoX digital transfer + Ethereum hash proof + QR for customs.
Customs Office	Requires stamped paper manifest	Customs may validate PDF eB/L with embedded QR linked to CargoX hash.
ERP (Manual Entry)	Staff update milestones manually	Azure functions + APIs write smart contract state + ERP milestone records.
IoT/ORBCOMM	Rarely used, or only at port arrival	Integrated to provide continuous tracking + smart triggers on arrival/handling.

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