Innovative Maritime Operations Management Using Blockchain Technology & Standardization

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Abstract

Modern economy faces one of its' greatest challenges of all times and disruptive innovations are available to corporations as solutions to major business drawbacks (e.g., traceability, communication, data exchange, information modelling etc.). The Maritime Industry combines multiple supply chain stakeholders and operations, globally, generating critical data and exchanging important documents. Mostly, these are paper-based and proprietary. For this industry, digitally exchanged data, must be unambiguous, semantically aligned between trading partners and shared with resilience in real-time using a common operational language. This could be achieved through the prominent from Bitcoin Cryptocurrency Blockchain Technology as a digital verification mechanism complying with global identification, technical and data exchange standards. Acknowledging the difficulties faced in the Maritime Business Operations' Management, this paper examines the strategic impact of Standards and Blockchain Technology in the industry's processes.

Keywords: Standards, standardization, blockchain, digital transformation, innovation, operations, shipping industry, maritime operations, shipping documents, disruptive technologies.

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1 Introduction

Modern Companies/Organizations, operating in the demanding "Industry 4.0" International Environment, are obliged to satisfy multiple needs, of various commercial and governmental partners. Business Operations' Management, through Digital Innovation and the selection of appropriate technologies, is a field of multiple discussions and experimentation for different Business Sectors.

During this "Information Era", business management is a continuing challenge. Automation in processes combined with the ability to monitor and manage data from different sources in real time provides numerous different characteristics to the business decision cycle. Modern business organizational structures are evolving from traditional pyramid hierarchies to decentralized and agile structures that enable faster decision making. These changes also favour better data processing from any kind of inputs and allow cross-functional executives and employees to work independently from anywhere around the world. This evolution is appearing to be well suited to the ongoing transformation that occurs both in the economy and the society. Furthermore, in the business communication spectrum, either internally or externally, information technology is a central pillar supporting the exchange and analysis of data and providing the fundamental knowledge for strategic decisions, which lead to efficient and productive resource allocation.

Several business requirements are forcing modern companies, investors, and entrepreneurs to re-design and explore digitalization opportunities in their operations. Nowdays, disruptive, digital innovations offer solutions to major business needs (e.g., traceability, communication, data exchange, information modelling and analysis). This development also affects the demanding maritime industry. Maritime companies in general face challenges like [1]:

1. Several protocols, specifications, Standards, Recommendations and Regulations have been identified which are scattered between different Organizations. Except from those causally related according to maritime safety (under the SOLAS Convention), the rest are either specialized (knowingly specialized), or less known.
2. Shipping is currently being introduced in digital innovation and solutions. However, the largest percentage of shipping companies (especially those operating in Tramp Shipping) in relation to the those operating in Liner Shipping (where in fact operations are more standardized) may be slow in adopting new technological trends, since there are not many initiatives to accelerate the adoption of digital innovations

and standardization in their processes. Therefore, those that do exist highlight small-scale, fragmented benefits.

3. The Shipbuilding Industry, although being a technical sector that could be directly affected by the "Industry 4.0 Era", delays the adoption of digital innovations. More than 60% of specialized executives in the Shipbuilding Industry believe that the industry will not take a significant digitization step by 2025 because of insufficient legislation, ignorance of the unknown, lack of trust, lack of education and fear of digital "cyber-risks".[1]
4. Shipping is governed by laws, regulations and sectoral or international trade terms that for decades have remained unchanged and accepted by all involved. Adjusting them (e.g., Rotterdam Rules vs. Hamburg Rules) is a time-consuming process that requires constant discussion among stakeholders, institutions, and companies.
5. Merchant Shipping is a sector of increased complexity in its' processes because it involves many risks, elasticity or inelasticity of supply and demand, natural conditions, and different business cultures and norms. Coordinating and drawing conclusions is a complex process to make strategic decisions.
6. Shipping is a traditionally "siloed" sector, highly competitive where information is critical and acquiring this information offers strategic advantage over competition.

We assume that these challenges create a mosaic of information, which is costly to manage and of high discrepancies' risk. Among the most dominant modern business strategies, of utmost importance is the need for complete, unique, publicly verifiable [2] and undisputable business data and metadata that lead to reliable management decisions and satisfaction of customer needs. The global nature of the maritime industry and the complexity of the collaboration between many different trading partners reinforces the need to achieve these results within maritime operations.

This article highlights the particularities and difficulties of the maritime sector. It then examines the contribution of standardization and blockchain technology in the provision of a secure environment for the exchange of information and the traceability of maritime business transactions. Finally, it shows how the combination of these technologies could lead to the development of digitally verifiable Maritime Operations.

[1]Digitalization on the way for shipping: Are we ready? (https://safety4sea.com/cm-digitalization-on-the-way-for-shipping-are-we-ready/) (2019).

2 Supply Chain and Maritime Operations

Operations management is the management of resources to produce and deliver products and services efficiently and effectively. It comprises of stages like sourcing, production, distribution and after sales services. Supply Chain Management integrates logistics and production processes. It is a key element of any enterprise balancing supply and demand across the entire value-chain, providing a cross-functional consolidation and management of flows (materials, information, financial), with the goal of effectively utilizing the supply chain resources, from raw materials to final products [3].

Modern supply chains face numerous challenges. They are influenced by different global trends that affect global trade and economy. The continuously changing economic conditions or trends influenced by the development of e-commerce, socio-political problems, or natural disasters (e.g., climate change, overpopulation, unforeseen pandemics like the Covid-19 pandemic) and changes in the consumers' habits are some general external factors [4]. Internally, some high impact challenges include and are not limited to capacity and resource availability, personnel management, lack of expertise, complexity deriving from the proliferation of products managed or manufactured and lack of business continuity and data sharing in products' development that lead to poor and costly manufacturing and marketing processes [5, 6]. Additional challenges include compliance needs with local and international laws and cost versus pricing issues, especially in certain industries like commodities or pharmaceuticals where price efficiency is critical [7]. These challenges are sometimes considered as a burden to agile supply chain strategies or lean business models. According to Groznik and Trkman [8] a way to mitigate supply chain risks is by applying operational frameworks and standards.

Maritime Operations are part of complicated supply chains. For every cargo transferred around the globe, a series of integrated and timely constrained set of supply chain activities precedes, so that consignors and consignees receive their consignment just in time and in sound condition. As underlined earlier, supply chain operations are a crucial integration of multiple corporate functions and stakeholders. Nevertheless, in a complicated business environment, lack of trust between stakeholders, limited or informal communication, and restricted information sharing leads to ineffective operations and quality problems. Therefore, to efficiently apply contemporary technologies and achieve optimal customer relationships, trust must be built as an integral part of supply chain and maritime operations. Trust, in collaborative business environments can be built by increasing transparency, collection and exchange of data and information. This requires an effective use of information and communication technologies in integrating processes, databases, and other operational resources. It can be fulfilled by establishing common values and standards, and by applying data analytics to become more corporate efficient [9].

2.1 Maritime Sector Stakeholders and Core Operational Elements

Shipping Companies are Organizations that participate to a large extent in international trade processes and carry out diverse activities in multiple locations. To understand the complexity related to the exchanged information, one must consider that maritime operations involve many different parties, each one playing a specific role in the shipping business. We can, briefly, distinguish the following [10]:

- Owners
- Classification Societies
- Charterers
- Operators
- Shipbrokers
- Ports which include not only natural locations (e.g., Berths, anchorages, etc.), but also a wider operation. They are mostly Intermodal Hubs that offer multiple, value-added supply chain services.
- Additional stakeholders involved are Ship Agents, Stevedores, Port Authorities, Customs and Port Facilities.
- Shipyards and Ship-repair Companies
- Ship Insurance and Underwriters (e.g., Protection and Indemnity Clubs (P&I Clubs), Hull and Machinery Insurance, Cargo Insurance etc.)

To further realize the complexity of the information exchanged between these stakeholders, one can identify the different types of vessels used in maritime transportation, which covers the 95% of Global Trade Transportation [11]. The most significant ones are:

- Tankers for transporting oil and their products, chemicals, liquids etc.
- Bulk Carriers for transporting dry cargo (e.g., iron ore, grains, cement, etc.)
- Containerships for transporting standardized containers of various types and dimensions

- Special purpose vessels for transporting special cargo (e.g., Ro/Ro for wheeled vehicles, inland barges for cargo transportation in mainland waters' channels, Dredges, Oil Platforms etc.)

Each one of the above can be found in the maritime market in different global trade routes and with various standardized capacities, dimensions, and characteristics. These lead to varied specifications and data related to the Vessels Dimensions, the Loading/Discharging Gear, which varies depending on the cargo type, and the Electromechanical Equipment and Shipbuilding Design specifications [10].

Finally, one can distinguish between the different types of cargoes, including General of Break Bulk Cargoes, Liquid or Dry Bulk Cargos and Container Cargoes.

2.2 Basic Maritime Operations

According to Stopford [12], there are four basic market sectors in which shipping companies participate, comprising the Freight Market, the Newbuilding's Market, the Second-Hand Market, and the Demolition Market. Each one of them has its' own specialized business needs and specifications as well as incorporates different sets of data captured and exchanged.

Maritime Companies' Operations are very specific and can be grouped as follows [13]:

- Business Development (Commercial) Processes.
- Demand Coverage Processes (including Vessels Chartering and Insurance, Voyage or Time Chartering, Bills of Lading, Letters of Indemnity etc.). It is critical to underline that a vessel's charter leads to a sequence of operations where issuing basic maritime documents is crucial. Moreover, the Operations involve quantities and types of cargo(s), loading and discharging geographical locations, with time constraints that need critical time events tracking and following specific quality standards. All these considering the necessary transport, crew, environmental safety standards are based on the existing international and national laws.
- Operations Management Resources: These include Support and Control Systems used to verify the performance of the Shipping Company at any level.

It should be noted that maritime operations are complex as their "active production units" or else the motor vessels are in constant motion and often at a great distance from their base, the headquarters, where the company is based and manages its fleet [13]. Therefore, key factors in all the above Maritime Operations are Time and Geographic Location. In terms of time, almost all Maritime Operations processes, documents, and stakeholders set as a point of reference the time in which they take place. Relevant indicators for monitoring Maritime Operations performance for vessels and ports are also characteristics, like the Port Turnaround Time and the Vessel Turnaround Time. Monitoring the timing and duration of operations is a critical factor. For example, the Estimated Time of Arrival (ETA) identification/briefing by the vessel's master is something that is constantly monitored by those involved. Ship tracking is implemented by Vessel Tracking and Tracing Systems (VTT). Additionally, locations are imperative for fast and just-in-time maritime operations. For example, in ports, exact data related to Port of Arrival, Anchorage, Loading/Discharging Terminal, Berths and Pilot Boarding and Dropping, are critical for a ship's master and are closely related to basic contractual obligations as agreed in the voyage or time charter party [14]. Finally, ports as multi-modal hubs serve in multiple aspects the maritime operations. The port-related stakeholders like shipping companies, terminal operators, and port agencies are actors whose decisions can play an important role in the overall supply chain performance [15]. A vital characteristic of successful operations is the integration of processes. Integration in ports is related to intermodality and organizational integration performed by global carriers to enhance their efficiency and get aligned with the industrial and commercial firms [16].

2.3 Basic Maritime Operations Documents

The shipping industry is based on many different processes involving the exchange of documents. The most basic documents of these processes are the Charter party, the Bill of Lading, the Goods Sale Agreement, and the Letter of Credit, which are presented below:

Charter Party

It is probably the most important Maritime Document. It is the "hiring" contract of the ship, a printed (and in the future fully digital) form of agreement between the Shipowners and the Charterers, of which the basic transportation terms derive from the agreed terms of the Sales Contract [10].

The Shipping Contracts proposed by BIMCO have been adopted by all Shipping companies because they have a standardized, clear structure, they are mutually acceptable, they adapt to the sales contract needs and have a wide variety of structures and clauses, conforming to the needs of cargo, charterers, and shipowners. It should be noted that they are one of the few clear Maritime Conventions that fit into the philosophy of Standards. Examples of BIMCO Charter Parties are 'GENCON 1994', 'BARECON 2017', 'BIMCHEMVOY 2008', etc. Charter parties differentiate depending on the maritime market involved (e.g., freight market (like liner trading, spot trading), new-buildings market etc.) yet they mostly include common types of stakeholders (e.g., consignors and consignees), locations and/or sub-locations involved in the processes (e.g., anchorages, ports, terminals, intermodal hubs, berths, shipyards etc.), cargo types, motor vessels involved (e.g., bulk carriers, tankers, gas carriers, containerships etc.). To achieve interoperability and unambiguous operations' information exchanged, all these charter party elements must follow a standardized identification of minimum data quality to become block parts in a blockchain network or smart contracts generated in the network.

Bill of Lading – B/L – BoL

The BoL is not a simple shipping document. It is a printed document (and lately digital), which acts as an "adhesive element" of all Maritime Operations. It is a binding document providing an ownership title between trading partners that proves that goods, as described therein, have been shipped by a specific ship, to a specific destination or have come into the possession of the shipowner for carriage through mutually accepted terms and conditions (those of the Charter Party) [17].

It is important to underline that BoLs, regardless of their type, generally have a specified structure and content including [10]:

1. Name, address, and contact details of the sender
2. Name, address, and contact details of the carrier
3. The vessel's name
4. The Port of Loading and Discharging
5. Name and address of the person or entity to be notified upon arrival of the goods
6. Cargo type and condition (number of packages or pieces, quantity, or weight (gross and net), identification marks)
7. Apparent cargo condition
8. Terms and place of payment
9. Number of original copies submitted
10. Applicable dispute resolution law

11. Transportation Conditions (e.g., FIO for Line Shipping, FOB/C and F/CIF for Tramp Shipping)
12. Place, date, and signature of either the carrier, the shipping company, the operator or the master of the ship or the authorized representative of any of them

Traditional paper-based B/Ls are of high-risk forms for loss or destruction. The issuance and management of paper-based B/Ls are time consuming and have high costs [18]. Issuance and management costs are estimated to exceed 15% of the physical transport costs. These drawbacks have highlighted the need for the development of Electronic Bills of Lading (eBL) for faster transactions' processing in the Maritime Sector. The use of electronic transactions in Shipping is estimated to reduce costs by 90% [18].

Due to the standardized structure and importance of these documents, the adoption of Standards to achieve semantic interoperability for data exchange is critical. The most used and approved by the International Association of P&I Clubs[2] are:

- BOLERO: Bolero eBL solution includes the Bolero Rulebook, the Bolero Title Registry, and the Bolero Messaging Platform.
- essDOCS including CargoDocs eDoc Exchange (DocEx) is a secure solution based on cloud computing technology that allows electronic signature, digital exchange, and legal transfer of documents.
- e-title™: It is a P2P technology that allows the creation and title transfer of negotiable documents, such as B/Ls.

Sales Contract

Contracts establish the successful cooperation between two different parties and validate the cooperation's reliability. Although in the Shipping Sector, the phrase "My word is my bond" is one of the most common to describe the long-term strength of mutual partnerships, yet international trade without contracts is an undeniable acceptance of serious risks and dangers.

The Sales Contract includes details agreed during negotiations [10], such as:

- Loading/Discharging Port (depending on whether INCOTERMS FOB/CandF have been selected)
- Delivery Time Period

[2]International Group of P&I Clubs website: https://www.igpandi.org/ (2021).

- Quantity, Quality of cargo and their relevant specifications
- Price and Payment Terms

As these data derive from an agreement, they are important and should be considered in digitalized processes.

Letters of Credit

Letters of Credit reduce the commercial transaction risks by shifting the obligation of payment from the buyer as an individual to a payment guaranteed by a legal entity (e.g., banks), in exchange for the presentation of compliant documents on credit terms by the seller.

A letter of credit is a document of high importance, which is directly dependent on other documents that must be verified for their uniqueness and authenticity. In the Maritime Sector, a letter of credit is essentially linked to the Charter Parties, affecting their terms, while it is also linked to the B/L. Therefore, digital traceability, uniqueness, and authenticity of transactions need to be achieved and ensured for its implementation.

The exchange of so many different documents between stakeholders shows the need for the development of standards in the Maritime sector.

3 Standardization and Standards

According to the European Committee for Standardization[3] (CEN European Committee for Standardization), a Standard[4] (French: Norme, German: Norm) *"Is a technical document designed to be used as a rule, directive or definition"*. It is a consensual, repetitive way of doing things. Standards are created by bringing together all stakeholders, such as manufacturers, consumers, and regulators

The Global Supply Chain Standards Organisation GS1 (former European Article Numbering Organisation) refers to Standards, from its own point of view, noting that *"... in an increasingly data driven world, standards provide a common language for identifying, capturing, collecting, and sharing supply chain data - ensuring that important information is accessible, accurate, and comprehensible"*.[5]

[3]CEN Website: https://www.cen.eu (Accessed: 2021).

[4]CEN – European Committee for Standardization, 'What is a Standard?', https://www.cen.eu/work/endev/whatisen/pages/default.aspx (Accessed: 2020).

[5]GS1 Official Website: https://www.gs1.org/ (2021).

Various definitions of standards can be found from multiple Standard Bodies. However, if we stress out the "key points" we can conclude that Standards are agreements [19], representing a consent for products and services and enabling the efficient management of processes. They may be agreed specifications, recommendations, instructions, or principles.

Standards and standardisation, yet many times confused as a common term, are in fact two complementary concepts since standardisation is the Standards' developing process while Standards are the outcomes of this process [20].

3.1 Standards Implementation Advantages

The use of Standards in Business Operations offers several advantages, measurable benefits and a competitive advantage for the companies that implement them. They are considered as tools promoting innovation, leading to socioeconomic achievements, and supporting sustainable development [21]. According to the European Committee for Standardization [22], a company that decides to apply Standards in its operations enjoys advantages such as:

- Positive perception and improved reputation
- Reduced costs, less waste and better efficiency
- Compliance with existing legislation (including EU directives)
- Higher levels of customer trust and satisfaction
- Access to the latest knowledge and technology solutions

Consequently, standards are a trust mechanism for corporate collaborations that may enhance the internal (organizational) and external (interorganisational) processes as well as lead to transaction cost reduction results. In a digital world, where complicated operations like those of the shipping industry generate severe information digital exchange, the availability of many business standards may not be useful. A key question relates to how standards can be efficiently implemented to offer best results at a supply chain level.

The European Project SELIS [23], aiming to develop a Shared European Logistics Intelligent Information Space in which organizations can share a common digital infrastructure to exchange supply chain information, shows that standards can solve critical issues in such collaborative global operations. The results of the project's pilots (or Living Labs, consisting of different companies across Europe that need to exchange information), showed some very interesting issues related to standards' application. The Project reported needs to deal with semantic harmonization, greater interoperability between digital systems and operational data exchanged, enhancement of intermediary message structures, encouragement to re-use global data standards, recognition of the international trade's global nature and embracement of new technologies and global standards. Therefore, it is essential that from the design phase, new technological developments are outlined to be scalable and able to exchange data using standardized API interfaces. This would make possible the application of global data standards, from early development stages, so that interoperability and unambiguous data exchanges are achieved.

3.2 Maritime Industry International Standards

Standards and interoperability are becoming more and more important in the maritime sector. If shipping and port enterprises want to benefit from benchmarking standardized operations, data should be comparable, and ship types, key performance indicators, definitions and parameters need to be standardized [24]. As there are many Standardization Bodies related to Shipping and Ports, many standards are applied in different maritime operations, lately focusing on digital data exchange and cyber security. Apart from standards published by the maritime industry's reference organization IMO (International Maritime Organization) (e.g., IMO Standard Marine Communication Phrases, Ballast Water Management Convention, SOLAS, FAL Convention etc.) the Maritime Regulations constantly refer to International or Regional Standard Bodies, such as the International Hydrographic Organization (IHO), the International Electrotechnical Commission IEC, the European Telecommunication Standards Institute (ETSI) etc.

There are various Shipping Industry Standards can be identified. For example, in the ISO 15583:2005[6] standard (last updated in 2019), a Maritime (technical mostly) standards' list is available. It comprises of existing ISO maritime standards and eight (8) shipbuilding nations of the world (The People's Republic of China, Germany, India, Japan, The Republic of Korea, Poland, Russian Federation and The United States of America) as of the year 2002. It classifies the maritime standards of the aforesaid organizations and nations into the codes that correspond to the existing organization of subcommittees of ISO/TC8, the Ships and marine technology ISO Technical Committee.

We can divide them in two general categories: *Technical Standards* and *Data Standards.* The latter are crucial for the Shipping Industry as data

[6]ISO 15583:2005 Standard (https://www.iso.org/obp/ui/#iso:std:iso:15583:ed-1:v1:en) (Accessed: 2021).

volume increases exponentially. These standards can provide useful strategic information for the Shipping Companies in relation to the international trade. In general, Data Standards can be segmented into two main levels:

- The "Data Type" Standards or the Data Models used for the communication of different systems to achieve interoperability in a semantic level.
- The Technical Data Exchange Protocols, which relate to technical secure communication between systems.

The Standards are interdependent. To maintain optimal data quality and interoperability between different systems, the minimum data set required to exchange between systems is first identified and determined. The standard "data dictionary" to be used is then decided (in other words the informational syntax of the messages, e.g., UN/EDIFACT, XML, JSON). Finally, technical data exchange protocols facilitate the secure data exchange between different systems (e.g., AS2, SOAP, REST, API).

For the maritime industry, the International Maritime Organization (IMO) has developed the IMO Compendium on Facilitation and Electronic Business. The data elements harmonization demanded during a port call and the standardization of electronic messages, helps the IMO Compendium to achieve ship-to-port information exchange and interoperability of single windows, which means a reduction in administrative operations for ships associated with formalities and ports. Hence, critical maritime operations become more efficient (e.g., Just-In-Time vessels port calls) where the quality and availability of data plays an intrinsic part and data standardization represents the primary fundamental step in the process [25].

As standards can help into achieving interoperability by standardizing critical operational data, a data collection, verification, traceability and consensus-based for all stakeholders' technology is required to maintain the integrity of the process. Blockchain Technology and its architecture, as it will be analysed in the next chapter, offer a decentralized digital consensus environment, where verifiable blocks of undisputable information can be recorded and transmitted to the blockchain network's nodes. Therefore, technical standards and specifications, directly related to certain maritime operational activities like vessels carbon footprint between voyages, safety of life at sea, vetting inspections certificates, fumigation certificates, motor vessels construction, containers stowage on vessels, spouts flawless loading of cargo on bulk carriers and others, are not associated with the digital, secured, decentralized information exchange and storage, which is the core blockchain function. The authors believe that the data generated by the above-mentioned operations can be modelled under identification and digital exchange data standards. Standardized data can be captured and recorded via the multiple innovative technologies (e.g., IoT, RFId, Sensors, Drones, etc.). Capturing can be performed in selected critical control points (e.g., berths or anchorages, warehouses, loading/discharging terminals, within a "smart" connected port) and be singularized with verified timestamps. If then recorded as blocks in a Blockchain ledger, with unambiguous tamper evident hashes that connect each block with its' previous ones in the network, then the concept of a traceable ledger based on Blockchain Technology becomes something feasible and really offers value to the maritime supply chain.

These standardized data sets in maritime blockchain networks can offer authenticated proof of operational actions that create mutual added value for the maritime stakeholders. Under this hypothesis, identification, data collection and semantically interoperable data exchange standards are critical for the successful deployment of blockchain technology in the maritime sector.

Therefore, agreeing and deploying mutually accepted standards in terms of data content and data exchanges, together with minimum data quality frameworks can lead to the development of a verification mechanism. As discussed in the following sections, this shall leverage the acceptance of blockchain technology in maritime operations.

4 Blockchain Technology

During the last years, Blockchain Technology has been introduced as a potential solution in the maritime industry. To this end, IBM and the maritime company A.P. Møller-Maersk have collaborated for the digitization, management and monitoring of maritime transactions worldwide using Blockchain technology. For this purpose, the two companies have established the research company "TradeLens[7]", which is managed by executives of the two parent companies. Its' core operation is to attempt and replace the current international hard copy-based transportation recording system of millions of containers per year, with a completely new digital infrastructure, based on Blockchain technology, that records with great speed, accuracy, and geographical transparency the status of each container, from the beginning to the end of each transport. This is not the only example and reference will be made to other applications in the following chapters.

[7]Tradelens Official Website (https://www.tradelens.com/) (Accessed: 2020).

As supply chains are international and often involve many stakeholders with complex relationships, many challenges occur due to the lack of trusted information. According to [26] due to its features Blockchain Technology can satisfy this need with compact solutions. Therefore, Blockchain Technology seems to be an important technological solution in the maritime industry's digitalization era.

The DLT (Distributed Ledger Technology) technology, on which Blockchain is based, is a consensus of reproducible, shared and synchronized digital data, geographically distributed across multiple sites, countries, or institutions. There is no central administrator or central data storage. Functionally, it is a decentralized database without a central authority, which uses CP/IP protocol to communicate between Peer-to-Peer network members [27].

4.1 Blockchain Technology Core Parameters

Extensive analysis of Blockchain technology can be found in multiple academic and non-academic sources, especially those published in the past four years (e.g., [2, 28, 29]). Without getting into many technical details, this paper underlines the basic parameters of Blockchain Technology [27], which are:

- The Blocks: Usually each Block contains transaction data and a Hash Pointer, which serves as a link for the previous Block [28, 30]. This way, it is impossible to delete any Block or insert a new one in the middle of a Blockchain chain, because then the fragmentation will not fit.
- The Nodes: Systems that store either a complete version of the blockchain and ensure the validity of the transactions ("full nodes") or part of it ("lightweight noded") are called "Nodes" [31].
- The Miners: The 'Mining' is the process of adding transactions to the large distributed public ledger of existing Blockchain transactions. It involves creating the hash functions of a Block transaction that cannot be easily copied, protecting the integrity of the entire Blockchain, without the need for a central system. Miners are therefore the user nodes that create a new block in the Blockchain. Practically, they concentrate all transactions together as a block, which is then added to the blockchain [32].
- The Hash Functions work like a "Digital Fingerprint" [33]. For Blocks to be attached to transactions data in Blockchain, a node must solve a Block hash function that satisfies certain mathematical conditions.
- The Consensus: For a Block to be included in a Blockchain, consensus of the network participants must be reached. This means that all

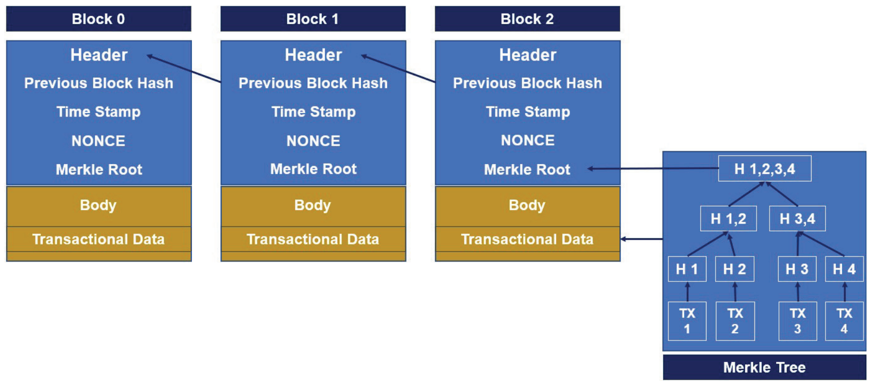

Figure 1 Blockchain block content [38].

participants in the network must confirm its authenticity. It is validated by all network nodes, until everyone has an updated Blockchain version.

In short, the operation of Blockchain consists of the following processes [34]:

1. The sending node records new data and transmits it to the network.
2. The receiving node checks the message from the received data and if the message was correct (it satisfies the Hash Functionality) then it will be saved in a Block.
3. All receiving nodes on the network run a Proof of Work[8] or Proof of Stake[9] consent algorithm on the Block.
4. The Block will be stored in the chain after the execution of the consensus algorithm, at each node in the network and if the nodes accept it.

The contents of a standalone Block are considered particularly important. As shown in the figure below [38], a Block consists of the Block Header and the Block Body [28]:

1. The Block Header includes the Block Version, the Merkle Tree Root Hash, the Date and Time Stamp, the Bits' count (nBits), the Nonce a 4

[8]An algorithmic model that is difficult (costly or time consuming) to produce, but easy to verify by others and meets certain requirements. It is debated about its' high computational need thus energy intensive nature [35] something that depends on the Blockchain design choices [36].

[9]It empowers virtual resources like a node's stake to achieve primary mining facilitation to maintain consensus in the network. A block is considered as correct if its' proof is correct with respect to all correct transactions that they confirm [37].

byte field which denotes with zero and increases for each hash function and the Parent Block Hash.

2. The Block Body consists of a Transactions Counter and of transactions.

It is, therefore, understandable that blocks have a predefined, standardized structure in technological terms yet mostly lack a standardized format of transactional data. This is an issue pinpointed in various resources [39, 40] and the challenge is to specify potential standards and methodologies to overcome it.

Blockchains can be divided into three main categories [34]:

- *Public Blockchains*: Anyone can access, participate, approve the completion of transactions, with absolutely no permission to access the register. Examples of such ledgers are Bitcoin and Ethereum cryptocurrencies.
- *Private Blockchains*: Only authorized persons can process a node to validate transactions. They also differ in terms of the consensus algorithm. Only nodes from a specific organization could participate in the consensus process. A private Blockchain is considered as a central network since it is fully controlled by an organization.
- *Consortium/Federated Blockchains*: It is an extension of Private Blockchains. This means that the node in power can be selected from the beginning, usually has B2B business partnerships, the data in Blockchain can be open or private and can be considered as partially decentralized. Hyperledger and R3CEV are both Consortium Blockchains.

As it will be explained in the following sections the structure of this technology can enable the use of standardized data and may change business processes.

4.2 Blockchain Technology Impact on Business Processes

Blockchain Technology has not only many advantages, but also weaknesses and usage obstacles. It's a main feature is the decentralized structure, which, together with transparency, sets new security standards [41]. As found in multiple sources [42–44], the major Blockchain Technology advantages for multiple business sectors are:

- Greater Security
- Improved Traceability
- Greater Transparency

- Reduced costs
- Increased efficiency and speed

Nevertheless, according to the same sources, specific disadvantages include Complexity, Network Size

- Transaction Costs and Network Speed
- Data Quality
- Possibility of Error Leakage
- Political Application Objections
- Unclear technological goals and objectives
- Lack of Standardization

It should be noted that besides the technological factors, data quality is also of great importance. For the maritime sector, data processing is fundamental to achieve sufficient operations. Even if a blockchain ledger is enriched with blocks of maritime data, a minimum data quality level should be achieved, to attain consensus so that the maritime blockchain maintains its reliability for all nodes and stakeholders involved. Decentralization does not imply uncontrollable data input for a blockchain network to be successful. Data Quality is challenged from the data diversity and complexity, the volume of data exchanged, the data short life and the lack of data quality standards to be followed [45].

There are many operations where the advantages of Blockchain Technology described above, in a technological and managerial level, are profound. Specific supply chain application areas for Blockchain Technology, directly connected to the maritime industry, are presented below [46]:

- Secured and free of errors orders fulfilment: Ordering in supply chain is mostly a composite and fixed process which includes steps like customer credit history confirmation, inventory status verification, financial status verification, order/shipment status notification and tracking/tracing of the entire order fulfilment process. Blockchain technology can automate this process and provide the necessary secured consensus mechanism speeding up the process.
- Assets Tracking: Whether a physical asset (e.g., a container, a train wagon, a pallet platform, a vessel etc.) or a critical document (e.g., contracts, Bills of Lading, cargo certificates, Letters of Credit etc.), Blockchain Technology can assert their uniqueness, origin, and ownership in an unambiguous level through the ledger, tracking and tracing of all related supply chain operations. Moreover, their physical

transportation and exchange can be unambiguously tracked while changing hands in global and open supply chains. This prevents the exchange of counterfeit goods or documents and allows a visible tracking through the ledger, which can identify the exact chain where a damage or loss has happened.

- Cybersecurity: Blockchain Technology due to its P2P architecture and end-to-end encryption can provide visibility and privacy to the transactions. It can be used for several security intensive applications involved in supply chain transactions like accounting and payment audits (e.g., freight payment audits, international payment audits).

Summarizing, Blockchain Technology may be considered as being complex, when compared to conventional central databases. Moreover, it has cost implementation limitations, which are though outweighed by the transparency benefits. These benefits are important for the transportation of fast-moving goods, such as food or pharmaceuticals, or premium products (e.g., high quality wine, jewellery etc.) of high value. Currently, the advantages of Blockchain Technology are better, when the trading volume of the respective trade items is low [41]. Furthermore, Blockchain technology can improve the level of supply chain cooperation by expanding trust between companies [47]. Finally, the ability of providing to modern consumers (of consumable products or services) or trading partners (in the maritime industry) reliable, immutable, transparent information founded on unambiguous data shared through Blockchain Technology, creates economies of scale which surpass the actual Blockchain implementation costs. This is significant for capitals and trade volume intensive industries like the maritime sector. After all, most of commonly consumed products are carried by sea and the maritime industry is an important chain in the broader demand satisfaction.

4.3 Smart Contracts

Smart contracts can be described as automated procedures for enforcing the terms of a contract [48]. More specifically, from an information technology point of view, they are lines of code that are stored in a Blockchain and are executed automatically when predefined terms and conditions are met. They are described as a program code or computer protocol that automates the verification, execution, and enforcement of certain terms and conditions of a "conventional" arrangement. At the most basic level, they are programs that run as regulated by the people who developed them. The benefits of smart contracts are most evident in business partnerships, in which they are usually used to enforce some form of agreement, so that all participants can be sure of the outcome without the involvement of an intermediary. By any means they are not digital contracts which often are based on authorization of a trustful source to achieve consensus and be executed neither they apply Artificial Intelligence principles in their execution [40].

The principle of smart contracts is the philosophy of a standard program code, i.e. "If/When (a condition is valid/not valid), then…" (if/when… then.) and is not recent. These "statements", depending on the transaction, are recorded as code in a Blockchain.

Connecting the smart contracts mechanism to maritime operations, could be a fundamental process in the supply chain, that may revolutionize shipping practice based mainly on maritime contracts (charter agreements) for the execution of core orders. Gradually, they are likely to replace many traditional contracts due to the speed of identification of those involved and structured execution of the steps. Their advantages, as defined in various resources [48, 49] are summarized as follows:

- Security: Blockchain transaction files are encrypted, and this makes them exceedingly difficult to counterfeit or intercept.
- Speed and accuracy: Smart contracts are digital and automated, so no handwritten documents are required. The computer code is also more accurate than the structure of traditional contracts.
- Trust: Smart contracts automatically execute transactions according to predefined rules and the encrypted files of these transactions are shared with the participants. Therefore, no one can dispute whether the information has been modified for personal gain.
- Cost savings: Smart contracts eliminate the need for intermediaries, to validate and verify the terms of an agreement, because participants can trust the visible data and technology to execute the transaction properly.

One major disadvantage is that the Smart Contract architecture is not to be corrected or upgraded. In other words, once the smart contract is loaded and used, it cannot be updated or corrected if there is a vulnerability, or an error found. Furthermore, contractual agreements (e.g., Charter parties in the maritime industry, Commodities Sales Contracts between consignors and consignees, etc.) must take into consideration all possible (even unexpected) events that might affect the contract's operation and describe countless combinations of external variables. Consequently, a dispute that might occur cannot be handled as a "code bug" but with a rationalized process based on the ones described in contractual terms [51]. Therefore, there is a need to devise new ways on the one hand to upgrade Smart Contracts and on the other hand to handle the ethical reporting of errors and vulnerabilities through legislation and standardization. Finally, it should be noted that introducing smart contracting in maritime operations, decreases costs, because of less manual operational efforts (e.g., for cargo quality checks etc.) and streamlined process time [52].

5 Deploying Standards and Blockchain Technology in Maritime Operations

It is evident that the Maritime Industry has certain needs during its ongoing digital transformation era. As proved in the previous sections, maritime transactions involve multiple stakeholders, critical events, held in different locations and business environments [1]. The hypothesis that every shipping stakeholder understands in a common manner the same concept in a global digital perspective is overrated, since commercial, transactional, financial and transportation data in combination with the various legislative obligations in local, international, and regional level create information, which must be thoroughly validated in every maritime operation step for its' uniqueness and integrity. Moreover, as global trade volume grows and unexpected events occur (e.g., COVID-19 Pandemic), customers demand traceable information for the cargoes moved across the globe. Traceability in the maritime sector does not solely refer to cargoes but also to the events related to cargoes since valuable elements of Maritime Operations like time, locations and assets involved are important factors. If they are not clarified and are of ambiguous quality, they may create unexpected time delays and consequently unexpected costs. In a vast global market, costs' shortage, and operations optimization, is imperative.

To better understand the article's subject, the authors will approach their proposition through a practical maritime operations example. In this example, a motor vessel will be employed to perform a voyage and carry bulk cargo from Piraeus in Greece to Rotterdam in Netherlands. We assume that the vessel (bulk carrier) is spotted in Piraeus anchorage ready to be employed by an exporter (consignor) and that it will discharge in Rotterdam 30,000 Metric tons of grains bought by the consignee. Although being an example, not based on actual details, the authors will try to incorporate as much of critical events and information as possible. The focus is to understand how standardization and standards could benefit the application of blockchain technology in the process.

Summing up the operations, we assume that the voyage is carried with the following critical events:

1. Consignee in the Netherlands, Utrecht agreed a goods sales contract with consignor in Greece for 30,000 metric tons of grains under negotiated fee per ton under ‘Free On Board’ INCOTERMS. An irrevocable Letter of Credit (L/C) is issued by consignee’s bank.
2. The consignor needs a motor vessel to execute the transportation’s voyage. They contact a chartering firm and appoint them to execute the transportation for certain commission.
3. The chartering firm, acting on behalf of their customer offer the cargo to potential customers.
4. Vessel owner’s shipbrokers match with the cargo and offer a handy-size bulk carrier M/V to the charterers.
5. Charter Party (BIMCO GENCON) is negotiated between charterers and shipbrokers and fix an agreement for the vessel. Agents are appointed and take control of port call processes.
6. The M/V has already issued a Notice of Readiness and it is ordered to enter Piraeus port and load cargo. Pilot boards, navigates to the berth, tugboats assist in berthing, stevedores’ gangs take control of the vessel and loading commences at day 1. For loading vessel gear is used.
7. Loading finishes at day 3, tally clerks confirm that cargo is sound, cargo declarations and documentation are verified and master signs clear ocean BoLs in three hard copies.
8. Voyage starts at day 3, vessel at average speed of 10 knots arrives at pilot station and Rotterdam anchorage on day 17. Humidity levels of the cargo remained at optimum level thus quality is maintained as delivered at port.
9. Pilot boards and navigates the vessel to the designated berth where discharge commences on day 18 and is over on day 20. Discharging operations performed with port’s gear.
10. Bills of lading are delivered to recipient and vessel signs off. Letter of Credit executed.

The above ten steps pretty much describe in good detail a carriage by sea operational flow.

During these operations, multiple stakeholders are involved. These are:

- The locations of loading and discharging and any sub-location involved in-between (e.g., anchorages, ports, berths, consignees, and consignor’s locations).

- The legal entities involved in the sales process (e.g., consignor, consignee, intermediate banks) and the transportation operations (e.g., vessel owner, charterers, shipbrokers, agents, M/V crew, port pilots, port authorities, tugboats operators, other authorities (e.g., sanitary, provisions, maintenance etc.).
- The M/V involved in the transportation operations and all associated data with it (e.g., ID, name, owner company, dimensions and cargo capacity, gear capacity, year and shipyard built, engine and speed specifications etc.).

Additionally, of extreme importance are the specific day and time information related to the operations. That is because pre-fixture processes must take into consideration ETA estimations to perform freight calculation while post-fixture processes should take into consideration costs occurred during operations (demurrages/dispatches) and validate against the published documents (e.g., BoL and L/C). Finally, port call operations must have this information available for optimized planning of the loading/discharging operations and any formal processes in-between.

In the example proposed, most of the information are collected manually, documents are also issued and signed hard-copy and monitoring of ETA time and locations is recorded with proprietary methods. Although many internationally recognized identification data are involved (e.g., IMO Vessel Number, Vessel Maritime Mobile Service Identity (MMSI), UN/LOCODE for locations, Company Identification Numbers (CID)) or mutually agreed global standards or conventions for the operations (e.g., SOLAS or ISO 17631:2002 (Shipboard plans for fire protection) for safety, ISO 20858:2007 for Maritime port facility security assessments and security plan development, the United Nations Convention on the Carriage of Goods by Sea, etc.) are followed and globally standardized contracts are involved in the operations (e.g., GENCON BIMCO charter party), in fact there is not any verification method that they are correctly implemented on the spot, there proprietary methods with which they are exchanged and many of the are manually filled-in which is a risk prone process.

This research shows that Blockchain technology, following a standardized process of data issuance and collection, in conjunction with operational identification and data exchange standards, that can create the basis of generating validated information on the spot, can be successfully implemented in the demanding maritime sector. Smart contracts and blockchain technology create a collaborative environment for business processes in the context of intelligent supply chains. Smart contracts, as a transactional method, together with the blockchain technology show potentials to ensure direct and without intermediates operations in maritime supply chains. Moreover, this information intermediaries' reduction is beneficial especially for small or entrepreneurial maritime stakeholders because it strengthens their competitiveness and efficiency since they face lower transaction costs and entry barriers due to the lack of intermediaries [52].

Therefore, unambiguous, interoperable real-time data, exchanged between stakeholders in an automated way that can be traced and verified at any moment from all stakeholders participating in the Shipping Industry is predominant. By using proprietary information, which temporarily may be cost effective but in the long run preoccupy resources and need mutual agreement or understanding between trading partners, maritime operations are conforming to silos that occlude potential business opportunities and a portfolio of global, potential customers. After all, the final recipient of any good carried by sea act needs one thing. To feel safe about the cargo's origin and authenticity.

Blockchain Technology offers exactly this assurance. Blockchain networks, in the maritime industry, can offer supremacy than the traditional world, because of real-time and tamper-proof records on blockchain [40]. This results to a relief for stakeholders and regulators about misreporting worries and time-delays, enabling the detection and containment of collusions and operational malfunctions at high frequency. By adding blocks of data in the Blockchain Ledger, constructed by mutually agreed and predefined standardized information, and approved through stakeholder's consensus, integrity and operations visibility can be achieved.

A good example of the situation AS IS now can be understood from the following scenario: In our example's the stakeholders (charterers, shipbrokers, owners etc.) agree to use BIMCO's standardized GENCON contract (GENCON 1994) (see specimen in Figure 2 below).

The C/P has a standardized hard-copy layout, requiring specific details to be filled in. Their structure is specific [12].

For example, in the BIMCO Charter Party 'GENCON' we observe standard details such as:

- Details of Shipowner/Charterer and Shipbroker
- Vessel Details (Name, Type, Capacity)
- Vessel's current position
- Freight agreed

BIMCO

GENCON 1994

UNIFORM GENERAL CHARTER **PART I**

1. Shipbroker	2. Place and Date
3. Owners/Place of business (Cl. 1)	4. Charterers/Place of business (Cl. 1)
5. Vessel's name (Cl. 1)	6. GT/NT (Cl. 1) /
7. DWT all told on summer load line in metric tons (abt.) (Cl. 1)	8. Present position (Cl. 1)
9. Expected ready to load (abt.) (Cl. 1)	
10. Loading port or place (Cl. 1)	11. Discharging port or place (Cl. 1)
12. Cargo (also state quantity and margin in Owners' option, if agreed; if full and complete cargo not agreed state "part cargo") (Cl. 1)	
13. Freight rate (also state whether freight prepaid or payable on delivery) (Cl. 4)	14. Freight payment (state currency and method of payment; also beneficiary and bank account) (Cl. 4)
15. State if vessel's cargo handling gear shall not be used (Cl. 5)	16. Laytime (if separate laytime for load. and disch. is agreed, fill in a) and b). If total laytime for load. and disch., fill in c) only) (Cl. 6) (a) Laytime for loading (b) Laytime for discharging (c) Total laytime for loading and discharging
17. Shippers/Place of business (Cl. 6)	
18. Agents (loading) (Cl. 6)	
19. Agents (discharging) (Cl. 6)	
20. Demurrage rate and manner payable (loading and discharging) (Cl. 7)	21. Cancelling date (Cl. 9)
	22. General Average to be adjusted at (Cl. 12)
23. Freight Tax (state if for the Owners' account (Cl. 13 (c))	24. Brokerage commission and to whom payable (Cl. 15)
25. Law and Arbitration (state 19 (a), 19 (b) or 19 (c) of Cl. 19; if 19 (c) agreed also state Place of Arbitration) (if not filled in 19 (a) shall apply) (Cl. 19) (a) State maximum amount for small claims/shortened arbitration (Cl. 19)	26. Additional clauses covering special provisions, if agreed

Figure 2 BIMCO "GENCON 1994" C/P (https://www.bimco.org/contracts-and-clauses/bimco-contracts/gencon-1994, Accessed: 1st February 2022).

- Details on the transported cargo
- Individual contract terms such as dates, points of cargo loading and discharging
- The operations duration (weather and holidays permitting)

- Payment terms and demurrages/dispatches costs
- Other penalties for non-compliance with the contract's requirements

Nevertheless, the data entered in the contract, even if mutually accepted, are totally under the discretion of the responsible actor that fills it in. We propose a different approach initially in terms of the contract's content. Each C/P data to be filled in could be based on mutually agreed standardized data. A potential concept is presented in Figure 3:

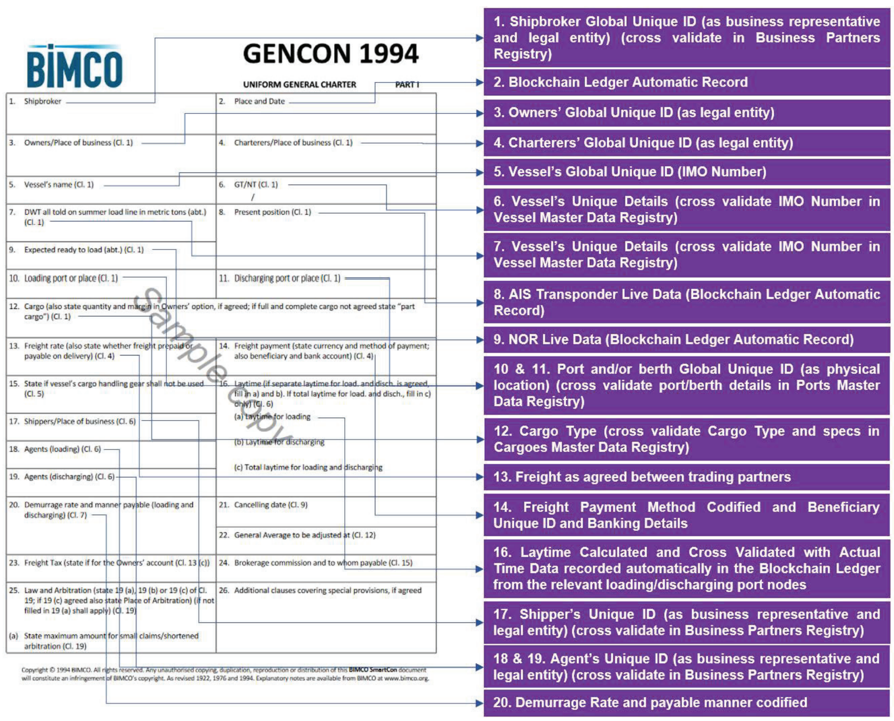

Figure 3 Unique and standardized identification of document elements as part of interoperable digital data exchange [1].

The contract (and any Maritime Operations document therefore) could be digitally exported (the Smart Contracts concept could be one way) and the event could be subscribed in a Maritime Blockchain ledger [1] following the consensus mechanisms of the technology. Elements of the contract (e.g., Cargo Quantity, Times related to operations etc.) could be also recorded in the ledger using automatic data capture mechanisms (e.g. IoT sensors mounted in the critical events points of interest) and data could be transmitted through global networks fast and accurate (e.g. satellite internet or 5G networks) [1].

One could question what type of Blockchain Network could record such verifiable transactions and what type of standards could be implemented. A federated blockchain network, where data in Blockchain can be open or private and can be considered as partially decentralized, seems the viable solution since different stakeholders can participate and flexibility, in terms of the data nature exchanged, can be achieved. Moreover, there are many standards which could be applied in such a blockchain network. For instance, ISO/IEC 19987:2017 EPC Information Services (EPCIS) Standard enables disparate applications to create and share visibility event data, both within and across enterprises and could be a serious candidate in terms of capturing blocks data in a standardized manner. The Standard focuses on exchanging structured supply chain events information digitally, related to physical movement and status of products as they travel throughout the supply chain – from business to business and ultimately to end-users/recipients [53]. It collects and models information answering to the fundamental questions of "Why" (that describes the business context under which the supply chain event took place), "Where" (in which location the event took place), "What" (identifying the physical or digital objects that were involved in an event) and "When" (the exact timestamp when a supply chain event took place).

Visualizing the above concept and taking into consideration the deployment of global standards to achieve interoperable processes (independent of the stakeholders' location and business processes), we identify three steps to achieve it (TO-BE).

First and foremost, agreement and application of a mutually accepted data quality framework [1]. The framework can be based on operations/processes importance and build layers of relevant data (see Figure 4):

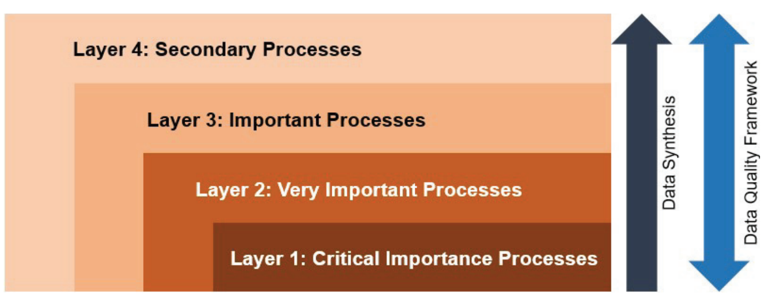

Figure 4 Maritime operations data quality framework [1].

Referring to our example, critical importance operations and data are the ones of contractual agreement processes (since they are associated to the commencing of all operations), while data associated for instance with the agent's name at ports of load and destination are necessary for the operations, but the relevant operations (cargo documentation, provisions, stevedores' employment) could be considered as very important, since they became critical as soon as the vessel is fixed. Having identified the criticality of the operations, the Data Quality Framework proposed assumes that each data associated with the operations is based on global standards: for instance, locations (e.g., port and country of load/discharge recognized with the relevant UN/LOCODE and/or ISO/IEC 6523 Global Location Number), vessels involved in the operations (e.g., bulk carrier, tugboats, pilot boats involved recognized with their unique IMO vessel number), legal entities (e.g., consignor/consignee, owners, charterers, agents, intermediate banks, port authorities etc. recognized with a GLEIF Legal Entity Identifiers and/or ISO/IEC 6523 Global Location Number), financial transactions (e.g., IBAN for accounts involved). Moreover, we assume that all maritime operations documents are issued digitally, depending on their criticality based on blockchain smart contracts (e.g., e-Contracts, e-BoL, e-Letter of Indemnity, e-Notice of readiness etc.) and they comprise of global standards-based data. It is important to underline that to achieve interoperability with other applications, outside the blockchain network, each document can be identified using as well global identifiers (e.g., ISO/IEC 15418). This is critical as soon as a blockchain network has not any intermediaries to verify the transaction therefore consensus must be associated with mutually agreed globally information, let alone for contractual agreements. The selection of the relevant data standards can be achieved following structured business information analysis (Figure 5). A relevant tool for this could be the UN/CEFACT Business Process Analysis [1]. The processing analysis is proposed by several international and intergovernmental organizations as a methodology to eliminate complexity and obstructions in the international trade [54].

As soon as the framework is in place, collection and processing of information is critical. Quality data, apart from being globally unique and verifiable to achieve unambiguity, must be real time especially for the maritime industry and blockchain networks functionality. In this, modern innovative technologies may give the solution. In our example, we assume that all data blocks mined in the network comprise of data that are captured and transmitted real time by using IoT sensors strategically placed in critical points of the operational locations. For instance, an IoT sensor place on the spout's nozzle at port of load can easily verify the volume per hour loaded on the vessel, thus giving at the beginning and in real time information about

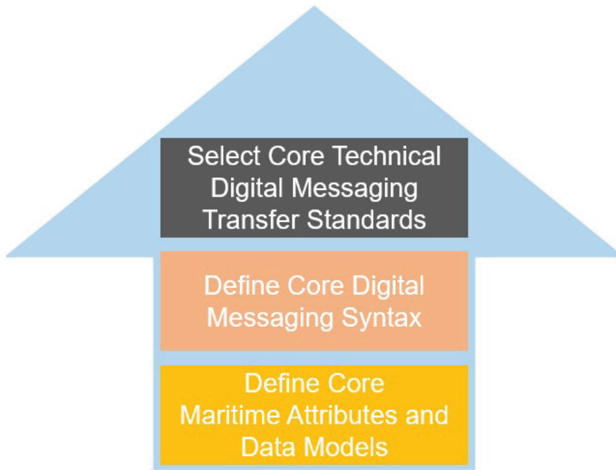

Figure 5 Structured maritime business information analysis [1].

when operations start/end as well as exactly the volume loaded. Additionally, IoT sensors in the vessel's cargo holds can register to the blockchain network data related to the conditions while loading and/or during the voyage, in real time, thus providing unambiguous data about the cargo quantity and quality. All these data would be associated with specific date and time stamps which is fundamental element of a blockchain's block.

Ultimately, before becoming blocks of the blockchain, interfaces built on machine learning and big data analytics principles could model the information and then add it as a block in the network. To achieve a consensus-based business environment, a dedicated maritime blockchain should be introduced. MarChain [1], a Blockchain Federated Network dedicated to maritime operations based on global standards could be the ultimate solution.

Therefore, in our example, the consignor and consignee, through an interface connected to MarChain (e.g., API, JSON based) can have real-time monitoring of all associated with the cargo information and location while the other stakeholders involved in the operations, from their associated interfaces connected to MarChain can access relevant data of their interest. Each node, after all, publishes unambiguous interoperable and global information which is registered and transmitted in standardized protocols thus achieving the relevant integrity of the concept. In other words, the stakeholders participate in a business transaction which does not generate costs for interpretation, minimizes ambiguity and takes full advantage of automations and technologies which offer fast decision-making facilitation and low-cost data availability. The agreed data quality framework and minimum set of data together with the global standards associated with the identification and messaging exchange standards can help the maritime stakeholders to optimize their operations, achieve operations and cargo traceability and share added value to the industry.

6 Challenges

Having emphasized, in the previous sections the biggest issues related to maritime operations, we can conclude that for stepping into digital transformation through blockchain technology the following are needed between stakeholders: Trust, Speed, Flexibility, Knowledge, Training, Innovation, Collaboration, Vision, Methodology, Common Thinking, Interoperability of Solutions and Decisions.

It should be noted that there are many international and regional Shipping Industry Organizations[10] that carry out their own work that may differ in purpose and scope [55]. They may not always share a common philosophy, which is founded on synergies, mutual collaboration, and basic agreements in terms of creating common industry practices and standards. Additionally, evaluating Blockchain Technology performance should include conventional performance measuring processes based on measures related to financial, tactical, and non-financial comparable metrics considering information systems efficiency and productivity while considering the upgraded role of digital technologies in digital supply chains [56].

It is understandable that achieving coherence and approval of blockchain applications in the maritime industry is limited, as soon as all these different stakeholders do not agree in a minimum set of standardized information to

[10]Examples include the following: International Maritime Organization – IMO, BIMCO (Baltic and International Maritime Council), International Association of Dry Cargo Shipowners – INTERCARGO, International Association of Independent Tanker Owners – INTERTANKO, World Shipping Council, International Chamber of Shipping., European Community Shipowners' Association, International Association of Ports and Harbors – IAPH, International Ports Community Systems Association – IPCSA, Federation of National Associations of Ship Brokers and Agents – FONASBA, International Association of Classification Societies, International Group of P&I Clubs, Cruise Lines International Association – CLIA, International Ship Suppliers Association – ISSA, World Customs Organization – WCO, International Federation of Freight Forwarders Associations – FIATA, World Trade Organization – WTO, Bureau International des Containers – BIC, International Chamber of Commerce – ICC.

be recorded and approved by them, assuming they are nodes of a blockchain network.

Moreover, regulations and other legislative acts (e.g., GDP Regulation, Directive (EU) 2015/2366 for Payment Services) clearly affect the implementation of Blockchain Technology as, without standardization, a data governance and verification cannot be successfully implemented. Furthermore, as Maritime Operations are part of intermodal supply chain operations, blockchain technology inevitably will be an inclusive technology where different stakeholders will need to share between them information even if they are not directly associated to maritime transactions. For example, a consignor from Ecuador needs to transport fruits to a consignee retailer in Europe. Although the products probably will be eventually carried with a containership in Europe, even before the maritime operation, different and complicated operations (e.g., harvesting, quality control, palletization, road/rail transportation, loading and unloading in different transportation modes and retail sale to consumer) must be tracked and traced. This creates an even bigger need to achieve alignment and a standardized data capture and exchange process for everyone involved. Consequently, the maritime blockchain should have the scalability to recognize and use data of other supply chains and even exchange data (from product identification to contracts and certificates) digitalized with other blockchain ledgers in an advanced interconnected, federated holistic blockchain network.

Finally, there cannot be a feasible success and escalating adoption of the technology without the engagement and training of all stakeholders or regulatory contribution. Thus, there must be relevant frameworks that need to be implemented to facilitate such engagement. We believe that success comes only when all intermediaries involved, from top management to daily operators, are positively engaged in such digitalization disruptions like implementing interoperable and innovative maritime operations through standards and Blockchain Technology.

7 Conclusions

The challenge of Business Standards for the Shipping Industry is that they should uniquely identify different entities, commodities, and documents throughout the Maritime Business value chain. There should be a structured way of collecting data, whether it concerns physical objects such as a consignment or a document, and finally there should be a structured way of communicating between those involved in the maritime chain. The data interoperability must be independent of the technological solutions to be used and not limited to the Shipping Industry. To achieve this, synergies between stakeholders, and structured deployment of innovations like Blockchain must be applied in Maritime Organizations.

However, the adoption of digital innovations like Blockchain Technology and interaction with other market segments can never be adopted unless there is at least a degree of penetrating the industry's "silos". For this reason, it is proposed to further strengthen the relations of the stakeholders in the shipping industry and redefine the concept of Maritime Clusters at regional and international levels. The key aspects and benefits of clustering are related innovation encouragement, specialization, and outsourcing. As discussed above, there can be no faster adoption of digital innovations, change of outdated regulations and more creative dialogue at a strategic level with institutions unless stakeholders agree in their own industry on minimum standards, regulations and set adoption schedules. No one knows the problems better and no one will better elucidate any adoption questions other than the Shipping Companies themselves.

Stakeholders involved in maritime operations, at the moment, mostly rely on proprietary solutions concerning data exchange, cargoes/assets identification and documents verification. As the maritime industry moves towards a digitalized future, proprietary information may support a stakeholder's internal operations, but will require time for interpretation and adjustment in the trading partners' systems. The costs involved in this process are a good reason to fully embrace standards when blockchain and other innovative technologies are about to be implemented in maritime operations.

The Maritime Blockchain solution proposed in this paper can break unnecessary silos between the industry's stakeholders and put forward real-time tracking of all cargo, documents, and locations (port, berth, gear) of the operations. Data exchanged standards (e.g., ISO/IEC 19987:2017) offer modelized way of collecting standardized information. The MarChain nodes share undisputable data and participate in mutually agreed, verified, and exchanged business transactions which do not generate costs for interpretation. It exploits any disruptive automation and technology since it is standards based. This means that it is not the technology or proprietary solutions the driver for achieving consensus. Additionally, as soon as minimum set of mutually agreed standards are exchanged, it creates a prosperous ecosystem where any stakeholder, independent of its' size, supply chain sector can participate and create growth opportunities. This is very important since the maritime industry is involved in larger multimodal supply chains. Consequently, MarChain and standards can be also a model for deploying relevant Blockchain ledgers to other industries. By supporting common, mutually accepted, and secure transactions, associated with accurate real-time timestamps, the authenticity and integrity of data can be achieved, while operating in a digital world.

To achieve a minimum participation level in such a ledger, a good initiating action recommended by the authors would be a regulatory enforcement or recommendation. Companies tend to better adopt disruptive business concepts when regulations lead them to do so. Large global organizations (e.g., EU, World Trade Organization (WTO), International Maritime Organization (IMO), World Customs Organization (WCO), International Association of Ports and Harbors (IAPH), etc.), which are striving to solve issues like counterfeit, digital transformation, sustainability etc., can take advantage of such a concept.

The authors believe that collaboration and perhaps regulatory adoption is a secure way of widespread acceptance of Standardized Blockchain Ledgers in the Maritime Sector.

Blockchain Technology and Standards, assisted by other disruptive innovations as presented in the journal, can help ensure this data continuity and integrity by capturing, processing, and uniquely identifying critical events data. As Oracle Organization underlines, "*...IoT "feels", Artificial Intelligence "thinks" and Blockchain "remembers""*. Therefore, remembering standardized information of demanding operations in crucial industries like the maritime industry is the future of supply chains and offers the necessary resilience to adopt new technologies efficiently, face the fluctuating trends of global markers and help shipping companies in their digital transformation strategies.

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