Improvement of the logistical performance of the container terminal at the Port of Oran

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Abstract:

This paper addresses the optimization of logistics performance at the container terminal in the port of Oran, presenting the challenges associated with flow management and port congestion. It forms part of an initiative to improve container handling operations, against a backdrop of increasing maritime traffic. The main issue concerns the organizational and operational constraints of the existing system, which lead to inefficiencies. The proposed hypothesis argues that a reorganization of processes and an optimization of flows could significantly improve overall performance. The approach is based on a diagnostic analysis of the terminal's operations, followed by the modelling of an optimized system. The article is organized into three parts: a diagnosis, a proposal for improvement, and a comparative evaluation. The results indicate a reduction in delays, costs and movements, and a marked improvement in capacity and operational efficiency.

Keywords : Ports ; maritime transport ; port logistics; port performance ; supply chain.

Jel Classification Codes : R41, L91, D24

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Introduction:

Over 80% of all goods exchanged worldwide go via maritime transit, making it the mainstay of international trade. As the world grows more interconnected, port logistics management is becoming more and more important to the efficient flow of products via ports, which serve as actual hubs for road, rail, and maritime networks. The 1950s saw the introduction of containerization, which significantly reduced handling, transportation, and storage costs and standardized operations, revolutionizing the industrial sector. Specialized container terminals, which are essential infrastructure enabling international trade, were established as a result of this development.

These terminals are of vital importance to the national economy, promoting exports and stimulating local development. However, they often experience recurring congestion, widely reported in the media, which causes delays, increases logistics costs and undermines the overall efficiency of the ports. The container terminal at the port of Oran is no exception to the problem of congestion. It was against this operational backdrop that we had to carefully inspect this facility, in order to determine the causes of its congestion and consider solutions to optimize its operation.

This work is based on a Master's thesis in industrial economics (Industrial Management and Logistics), written by Mounia Bessol and Maroua Bentabet at the National Polytechnic School of Oran, under my academic supervision. This applied research, which focuses on optimizing processes at the container terminal in the port of Oran, forms the scientific basis of this article. This collaboration between the students and the supervisor combines valuable first-hand observations with academic expertise in logistics modelling. It draws on considerable practical experience: a placement at the EPO, interviews with the head of procurement and the head of imports/exports, an exploration of the scanner inspection area, and the analysis of historical internal data.

We begin by presenting the context, examining the terminal's operational scope and identifying the main challenges. This leads us to the following key question: **How can we maximize the Port of Oran's underutilized potential to turn it into a catalyst for development while reducing losses like ineffective movements and stagnant periods and increasing resource utilization efficiency?**

The best way to solve the operational inefficiencies at the Port of Oran is to revise the container management procedures. Therefore, by analyzing existing operations and modeling an optimal future scenario, our work seeks to implement concrete improvements to container management procedures in order to lessen congestion at the Oran terminal. The approach is broken down into three main sections: (1) the basic ideas of logistics and port logistics; (2) an overview of the Port of Oran, its container terminal, and the EPO; and (3) a thorough analysis of the terminal and the steps taken to enhance container management. An overall conclusion is presented at the end of the study.

The first part of our work aims to set out the fundamentals of global logistics, followed by a more detailed study of port logistics. These theoretical principles form the basis for the study of the Port of Oran's container terminal and the resulting proposals for improvement.

I. Fundamental concepts:

1. Fundamental concepts of logistics:

In modern businesses, whether industrial, commercial or service-based, logistics is of strategic importance. It encompasses all operations relating to the structuring, organization and control of the flow of goods, information and services, from their point of origin to the end user. The primary objective is to optimize operational efficiency whilst controlling costs and maintaining excellent customer service.

1.1 A key role in the organization is logistics:

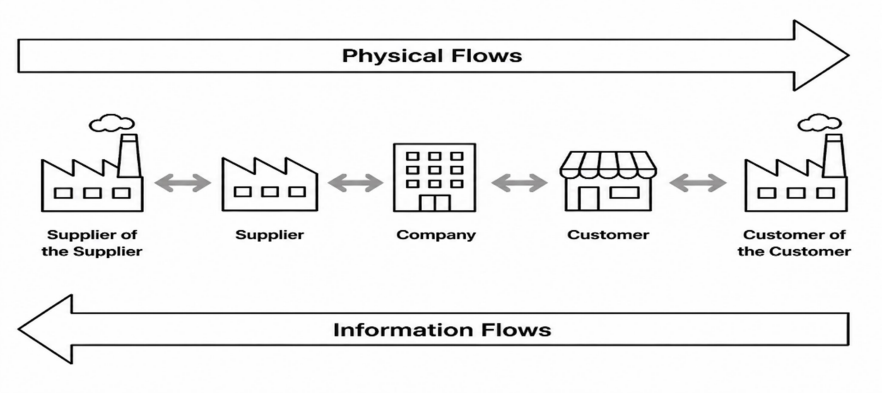
Historically, the concept of logistics has its origins in the military and mathematical fields. In a military context, it refers to the arrangement of resources, troop deployments and support infrastructure. From a cognitive perspective, it evokes rational thinking and methodical organization. These two interpretations have converged to create contemporary logistics, focused on the harmony of flows within the organization.

Logistics therefore ensures essential synchronization between production, sales and finance, by aligning production capacity with actual demand, reducing delivery times and minimizing storage and transport costs. Logistics, having gradually become an essential element of competitiveness, transforms businesses into more flexible and resilient organizations.

1.2 Flows and logistics development:

Logistics is based on two fundamental flows: the physical flow and the information flow. The physical flow refers to the actual movement of goods throughout the supply chain, including transport, handling, packaging and warehousing. The information flow coordinates these operations by sharing information regarding orders, the location of goods, available stock levels, demand forecasts and exchanges between various stakeholders.

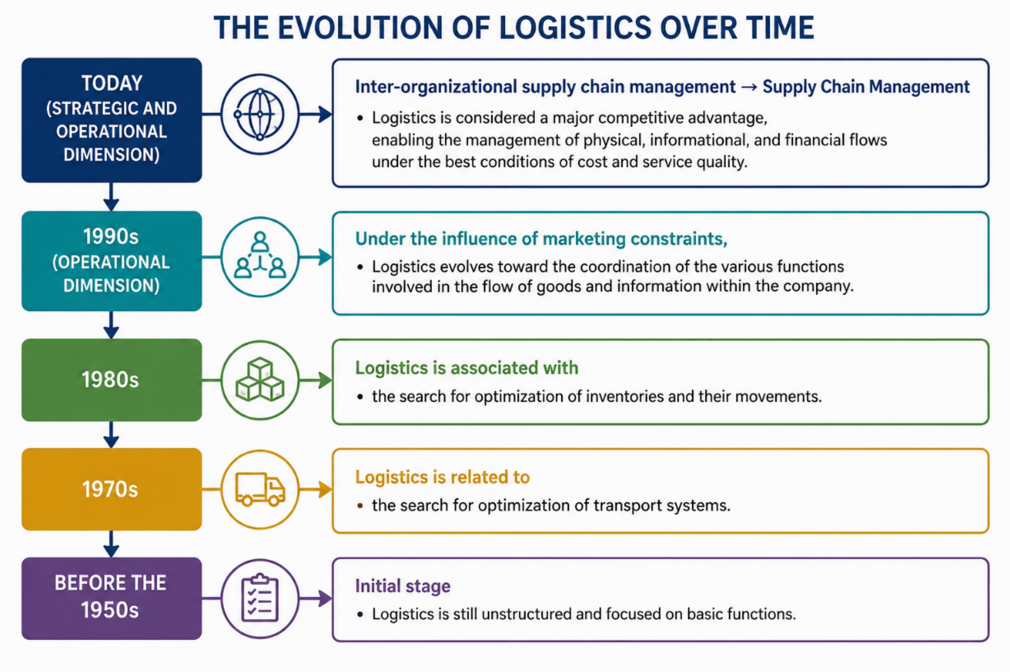
Fig. 1: Logistics flows



Source : Gautrin, 2013
https://www.faq-logistique.com/GCL-Logiguide-Vol08Num01-Gestion-Chaine-Logistique.htm

These two flows form part of an overall structure that establishes the link between the supplier and the end consumer. Logistics coordinates this system to minimize stock-outs and reduce the costs associated with waiting and storage, whilst maintaining a first-class service. It encompasses not only the management of movements, but also the organization, coordination and control of human, material and information resources.

Fig. 2: The stages of evolution in logistics



Source: Lyonnet and Senkel, 2015, p.15

The evolution of logistics took place in three distinct phases. The initial phase, known as the 'intra-functional' phase (1950–1975), was characterized by a period of mass production in response to strong demand in a dominant domestic market. The next phase, commonly referred to as interfunctional (1975–1990), aimed to respond to the economic crisis by minimizing costs, optimizing quality and encouraging gradual international expansion. Ultimately, so-called "open" logistics, which emerged in the 1990s, relies on innovation, globalization and product diversity whilst operating in a context of uncertainty regarding demand (Lyonnet and Senkel, 2015).

1.3 The logistics chain and supply chain management:

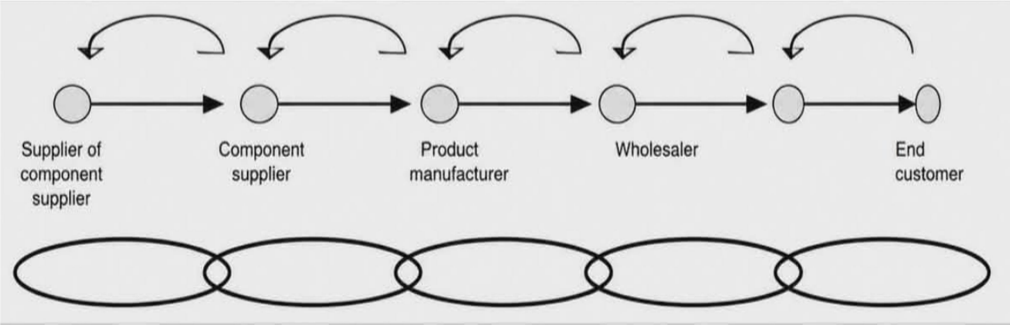
The supply chain broadens the scope of logistics by encompassing all phases from suppliers to end consumers. It encompasses the conversion of raw materials into finished products, their transport, storage and distribution, whilst harmonizing material, information and financial flows. This holistic view regards participants as interdependent elements of a coherent system.

Supply chain management (SCM) coordinates and optimizes the actions of these stakeholders, from suppliers to end consumers. It seeks to improve overall efficiency by controlling costs, reducing delivery times and enhancing customer satisfaction, despite internal and external constraints. As a result, SCM relies on close collaboration, information sharing and complete transparency of flows.

Although logistics does not take into account all strategic and relational aspects, it remains a fundamental element of the supply chain. In contrast, supply chain management encompasses planning, coordination and collaboration between companies, as well as risk management and

external partnerships. This distinction highlights the importance of a systemic vision that extends beyond internal organizational boundaries.

Fig. 3: Schematic representation of the supply chain



Source: Pimor and Fender, 2016, p.11

2. Fundamental concepts of port logistics and containerisation:

Port logistics is a specific branch of logistics that focuses on operations related to seaports. It encompasses the loading and unloading of ships, container supervision, temporary storage, cargo management, and the planning of journeys to road or rail networks. As such, the port acts as a vital multimodal hub, ensuring the continuity of international supply chains.

In this context, port logistics plays a crucial role in global trade. It facilitates the transfer of goods from the maritime to the land-based environment in an organized and secure manner. This ensures the smooth flow of transfers, reduces delays and enhances the competitiveness of ports and the economies they support.

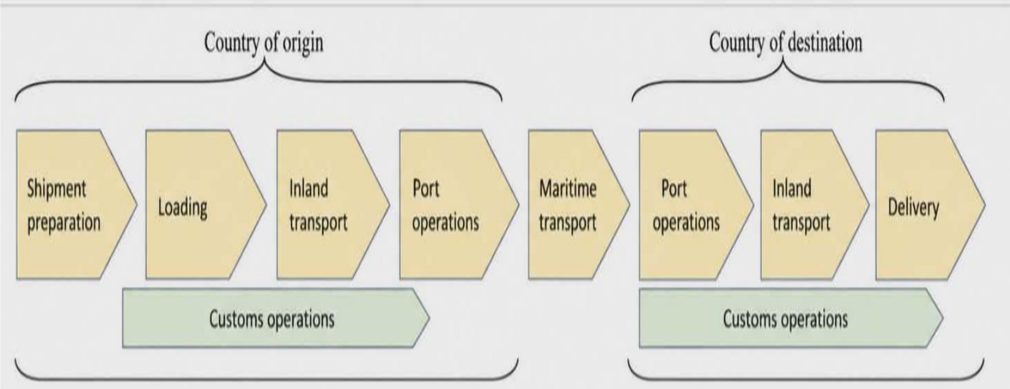
Port logistics is implemented at three distinct levels. At the operational level, it is responsible for coordinating the use of quays, cranes, storage areas and internal routes. At the organizational level, it manages coordination between various stakeholders such as shipowners, transport companies, port operators, as well as authorities, customs and security services. In short, at the economic level, it reduces transport costs, improves efficiency and maximizes the profitability of port operations.

2.1 Port logistics chain and stakeholders:

The port logistics chain encompasses all the processes and stakeholders involved in the management of goods within the port. It has highlighted the crucial role of the port and its terminals as essential elements of the global supply chain. It begins with the arrival of the vessel, continues with the unloading process and the handling of cargo on the quay or in a warehouse, and concludes with the transfer to land-based networks and delivery to the end customer.

Dockers, who are responsible for loading and unloading ships, as well as internal transporters who move containers within the port, are key players.

Fig. 4: Port logistics chain process



Source: Thommerel, 09/12/2022, What is port logistics?
https://blog.xplog.fr/logistique-portuaire-d%C3%A9finition

Port operators oversee operations, whilst the material and administrative preparations for receiving and storage are managed by port handlers. Shipowners coordinate maritime transit, whilst shipping agents represent the shipowners in receiving and distributing goods.

The efficiency of the port supply chain depends on smooth collaboration between the various stakeholders. The aim of synchronizing operations through port logistics is to avoid delays, congestion and wasted time **(Benghalia, 2016)**. It is therefore crucial to skillfully manage physical and information flows to ensure the efficient distribution of goods through the port.

2.2 Containerisation and the revolution in maritime transport:

The use of standardized metal containers, suitable for a wide variety of products, has transformed maritime transport. Dating back to the 1950s, this technological innovation is based on the transport of goods in self-contained units, moved between ports without interrupting the loading process. It improves safety, reduces packaging waste and increases the efficiency of ships and ports.

Malcolm McLean, an American engineer, popularized this idea, drawing inspiration from the military containers used during the Second World War. It began to spread across the North Atlantic in the 1960s, before becoming a global standard.

In 1974, the ISO standardized its dimensions and technical specifications, thereby creating a universal standard. It enables multimodal transport, as the container is moved from the ship to the lorry or train without being unloaded, thereby reducing handling operations, the risk of damage and transit times. As such, containerization is considered essential for the globalization of trade (FREMONT, 2007).

2.3 Types of containers and standardized dimensions:

Various types of containers have been developed to cater for the diversity of goods. The dry container, also known as the standard container, is the most common type and is used to transport

the majority of non-perishable goods, such as manufactured goods, industrial components or packaged goods. The refrigerated container, commonly known as a Reefer, ensures temperature control. It is therefore essential for the preservation of perishable goods such as food, agricultural products or certain medicines.

The Tank container is specially designed for the bulk transport of liquids, such as chemicals, oils or certain liquid foods. The flat-rack container, which has open sides, is ideally suited to the transport of large goods such as machinery, cars or heavy industrial equipment. The Open Top container, which features an open top, facilitates loading from above for large or very tall items. Finally, High Cube containers offer greater height than standard containers, making them particularly suitable for loads requiring more vertical space.

These various categories of containers are designed to meet specific requirements regarding security, temperature, stability and geometry. They also influence how ports organize their facilities, storage areas, handling equipment and loading and unloading procedures. ISO standards, such as those for 20, 40 and 45-foot containers, specify parameters for length, width, height, volume and load weight that ensure the efficient management of port capacity **(Kassabian, 2022)**.

The growth of ports is closely linked to the development of maritime transport, whether in terms of the volume of goods traded or the diversity and size of ships. Ports handle a wide variety of cargo, amongst which containers play a dominant role. Containerization has played a crucial role in the transformation of global production and distribution: not only has it helped to reduce maritime shipping costs and make this solution more cost-effective, but it also offers a multitude of benefits for managing goods within terminals and preserving their quality during transport.

Container terminals, a central element of port logistics, are specialized facilities located in seaports and dedicated exclusively to container handling. This transition naturally leads us to the second aspect of the article: Classification of ports and organization of terminals.

Consequently, the EPO plays a crucial role in coordinating stakeholders and procedures within the container terminal at the Port of Oran. This transition naturally leads us to the second aspect of the article: Classification of ports and organization of terminals. Handling equipment and devices, Efficiency of terminals in Oran, Port of Oran, Oran Port Authority and private terminal.

II. Classification of ports and terminal structure:

1. Ports and their main categories:

A port is a geographical and economic entity, precisely located on the shores of a sea, river or lake. Its primary role is to accommodate vessels and facilitate the movement of goods and passengers between waterways and land transport routes. Its facilities are established both on land and at sea and provide essential services to ships, passengers and goods, in order to ensure the efficient execution of transport operations and to facilitate the growth of global trade, industry and, more broadly, the economies of the countries within its sphere of influence **(Scherrer, 2011)**.

Ports can be categorized according to various criteria. Based on their geographical location, ports are classified as seaports, river ports, dry ports or lake ports. Ports, which serve as points of convergence between maritime and land transport, are also of vital importance as telecommunications hubs for managing data relating to the movement of ships. River ports, located on navigable waterways, facilitate the loading, unloading and transfer of goods and

passengers between river and land transport modes. Inland ports, located in inland areas, are usually connected to seaports by rail or road. To ease the strain on the main ports, they provide container administration, storage, and occasionally repair services. A range of vessels, including pleasure yachts, fishing boats, ferries, and occasionally cargo ships, are accommodated in lake ports, which are located on the borders of lakes or other freshwater bodies. They support the growth of inland navigation and water-based tourism (Scherrer, 2011).

In summary, there are three categories of ports: first-generation ports, which focus on the basic connection between goods and the vessel; second-generation ports, commonly known as industrial ports, which incorporate areas dedicated to the processing of goods; and finally, third-generation ports, which are fully integrated into supply chains and production systems, offering sophisticated services and a high level of interconnectivity.

2. Container terminals and their operational areas:

The concept of the container terminal stems directly from the rise of containerization in maritime transport, which led seaports to establish infrastructure dedicated to the management and storage of containers. A container terminal is an area specially designed to carry out import and export operations, comprising quays for loading and unloading ships, storage areas dedicated to containers, and appropriate handling equipment.

According to port information, a terminal consists of various key areas divided into two main sections: the quay area and the yard. The quay area encompasses the space where ships call, as well as the gantry cranes or quay cranes responsible for container loading and unloading operations. As for the yard, this is the area where container storage, transport and dispatch to land vehicles take place.

Four distinct functional zones can be identified within the terminal. The maritime interface serves as the entry and exit point for ships, where efficiency is measured in particular by the reduction in dwell time. Next is the internal handling area, where containers are moved between the quays and the storage areas; the storage area itself, organized into sections and aisles; and finally, the land transport area where containers are loaded onto lorries or trains. Each area presents specific challenges, whether in terms of quay management, vehicle traffic or the optimal use of storage space **(Dadie, 2021)**.

2.1 Handling equipment and machinery

A container terminal relies on various types of equipment to ensure the smooth running of its operations. Stacker cranes are capable of manoeuvring and stacking containers on multiple levels, whilst loading them onto lorry trailers. Port tractors and trailers move containers between the quay and storage areas, whilst container stacking is optimized through the use of rubber-tyred or rail-mounted gantry cranes (RTGs).

Automated guided vehicles (AGVs) help to modernize terminals by ensuring a smoother, more synchronized movement of containers. Reach stackers simplify container handling on quays and in storage areas, as well as their loading onto trains. With the introduction of forklift trucks designed for empty or loaded containers, our range of handling solutions is expanding, thereby facilitating their movement, loading and stacking according to the terminal's needs. All these mechanisms help to improve productivity whilst reducing vessel waiting times **(Camso, 2021)**.

2.2 Terminal productivity

Major container ports operate in accordance with industry standards, with the aim of ensuring maximum productivity and efficient flow management. Key indicators include vessel turnaround time, quay occupancy, gantry crane performance, the annual workload of equipment, available space in storage areas, and quay length. Productivity is generally measured in terms of containers handled per hour or per unit of area, to gauge the efficiency of operations on the quay and in the storage area.

These standards illustrate the expected performance in major ports worldwide, whilst serving as criteria for the evaluation of terminals under construction, as is the case for the Port of Oran. To achieve these levels of productivity, it is essential to ensure alignment between equipment, the organization of flows, and the management of human and material resources.

3. Port of Oran, EPO and dedicated terminal

The Port of Oran is a key logistics hub for western Algeria, playing an important role in trade between Algeria and Europe. This section begins with a presentation of the port and its historical and geographical context, then highlights the importance of the Oran Port Authority (EPO) in its management and expansion, before focusing on the container terminal and its operational capabilities.

3.1 The Port of Oran: Geography and Infrastructure of the Subject Under Study

The port of Oran has its roots in antiquity, having been founded in the 10th century under the name OUAHRAN, which translates as 'the two lions'. During the Almohad era, it enjoyed a period of prosperity and was regarded as a major port of the empire, serving as the link between the central Maghreb and the European ports of the Mediterranean. Located approximately 400 km west of Algiers and built at the foot of cliffs, the port enjoys a strategic location, situated at the crossroads of the main shipping routes linking Western Europe to the Suez Canal. Furthermore, it lies at the heart of trade between Algeria and Europe. This port, which is always accessible, is equipped with navigation, towing and maneuvering facilities that ensure the entry and exit of ships through an opening 150 metres wide and 25 metres deep. It allows the mooring of ships capable of carrying a heavy load of up to 35 000 tonnes. The port infrastructure comprises various basins, commercial quays and storage areas, as well as specialized facilities such as the grain silo, Ro-Ro ramps, storage warehouses, trailer parks, the maritime terminal, navigation aids and a variety of handling equipment. These facilities give the port of Oran the capacity to handle over 8 million tonnes of annual traffic, with a hinterland covering the entire western part of the country (Louhibi & Benkada, 2007).

3.2 The Oran Port Authority (EPO):

The port's long-standing development includes the history of the EPO as a key element. Its origins date back to Mers-el-Kébir, a former port of Oran, and it gradually developed over the centuries, culminating in the creation, in 1982, of a single entity combining the functions of the National Ports Office, the National Handling Company and the CNAN. The EPO is a public economic service company, managed by the Port Holdings Management Company (SOGEPORTS) and placed under the supervision of the Secretary of State for Fisheries and Maritime Transport.

The port of Oran possesses a range of physical and operational capabilities that make it indispensable to western Algeria. To present these capabilities clearly and concisely, a summary

table will be included later in this report, providing detailed information on storage capacity, handling equipment, navigation services and all the infrastructure that makes the port of Oran unique.

The EPO manages, operates and develops the port of Oran, whilst also being responsible for security and control within the port area. It manages the movement of people and goods, directs handling and reception operations, supervises towing, pilotage and mooring activities, whilst also overseeing tasks related to security, storage and maintenance. It is also responsible for supervising the fishing and leisure port, the passage of passengers and vehicles, as well as development and safety operations related to the port.

3.3 The container terminal at the Port of Oran:

The Port of Oran has a container terminal divided into two main sections: the old terminal, covering an area of 12 hectares and featuring several berths, with an estimated storage capacity of approximately 6 000 TEU; and the new terminal, which resulted from the expansion carried out by the Algerian-Chinese consortium. This expansion has enabled the integration of 16.5 hectares of water area, the construction of a 460-metre-long jetty capable of reaching a depth of 14 metres, and an increase in the terminal's total capacity, with the aim of handling over one million containers per year and accommodating Panamax-class vessels.

The terminal is divided into three main sectors: the port area, dedicated to the loading and unloading of ships; the storage area, organized into sub-zones for the stages before, during and after a ship's call; and finally, the land area, which manages lorry movements as well as activities related to the arrival and departure of containers by road or rail.

The terminal is equipped with quay cranes, scissor lifts, container handlers, internal trucks and marine trailers, in addition to forklift trucks. Their layout is tailored to the specific needs of each sector. This diverse range of equipment facilitates the performance of handling tasks under optimal conditions and enables the terminal to evolve towards standards comparable to those of major international ports.

Table 1: Number of pieces of equipment at the Oran container terminal

Type of equipment	Number
Ride-on stackers	05
Reach stacker	05
Internal transport truck	07

Source: Data collected through a survey of EPO managers

In short, logistics, particularly port logistics, plays a crucial role in the efficient management of the flow of goods, information and services within ports. The EPO perfectly illustrates these challenges by bringing together the staff, equipment and infrastructure necessary to ensure the efficiency of its operations, whilst committing to a process of continuous improvement of its services. This is precisely what we aim to achieve with our empirical study.

This second point has enabled us to explore the fundamental concepts in greater depth, providing a basis for the rest of our article, which is dedicated to more efficient port logistics within the container terminal at the Port of Oran.

The third section offers a detailed and forward-looking study of the activities at the EPO

container terminal, focusing on the economic optimization of cargo movements, the reduction of costs and the enhancement of competitiveness. This empirical research identifies current issues and proposes an improved model, compliant with international standards, to stimulate regional development through efficient logistics.

III. Context and methodology:

1. Economic and strategic context of the Oran terminal:

The Port of Oran, a crucial logistics hub for western Algeria, is handling a steady increase in container traffic, with approximately 250,000 TEUs of imports recorded in 2023. This is occurring against a backdrop of rapidly globalizing world trade. This performance has a direct impact on the local and national economy: reduced processing times simplify the essential importation of everyday consumer goods, industrial equipment and raw materials crucial to the agri-food and construction sectors, whilst boosting exports by local small and medium-sized enterprises to Europe and sub-Saharan Africa. Furthermore, it helps to reduce additional logistics costs, which frequently account for 20–30% of the final cost of products, thereby preserving the competitiveness of the industrial and commercial sectors. The research addresses a key economic question: **How can an underutilized terminal be transformed into a catalyst for growth, by minimizing losses (unproductive journeys, periods of inactivity) and through the optimal allocation of resources?**

2. Methodology: A field-based and quantitative approach:

The methodology adopted combines qualitative immersion and quantitative analysis to ensure greater economic validity:

2.1. Structured interviews:

With the procurement manager (day-to-day practices), the imports/exports manager (historical data) and a freight forwarder (overview of the global supply chain, competitive challenges).

2.2. On-site observations:

Visit to the scanner area (role in customs inspections) and mapping of physical flows.

2.3 Quantitative data:

Monthly traffic for 2023, equipment throughput rates, processing times.

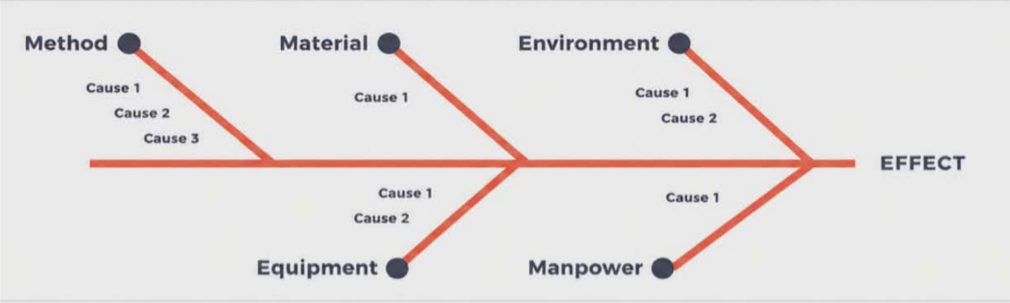
This three-pronged approach ensures analytical robustness by eliminating theoretical biases, resulting in an operational diagnosis that can be directly applied within the framework of port economic policies.

3. Diagnosis of malfunctions:

3.1 The Ishikawa diagram as a tool for causal analysis (5M):

The analysis uses the Ishikawa (Poisson) diagram, a classic economic management method, to resolve inefficiencies and determine root causes. This diagram organizes the sources of anomalies into five main categories: personnel, physical resources, techniques used, the environment and materials (in this context, container flows). This method highlights a series of structural deficiencies.

Figure 5: Ishikawa diagram (5M)



Source: Axel Lefebre, 8 November 2024, The Ishikawa Diagram
https://blog.xplog.fr/logistique-portuaire-d%C3%A9finition

a. Method: Inefficient flows and chaotic organization

Current methods involve cross-flows (unloading to storage followed by inspection, with numerous returns), without any optimization of flow mapping or digitization. The lack of lean procedures (such as 'one-touch' processing) leads to a proliferation of non-productive movements (estimated at 2–3 per container compared to an ideal of 1). This methodological inflexibility, a problem stemming from an outdated structure, hinders the ability to adapt to increasing volumes (250,000 TEUs/year) and obscures potential efficiency improvements of 30 to 40%.

b. Material:

The diversity of containers (non-standard dimensions, refrigerated or overloaded types, damaged packaging) makes it difficult to ensure stability during storage and during scanner checks. Customs rejections and additional operations are caused by unexpected surcharges (discovered after the fact) and undeclared hazardous substances. This increases the risk of accidents and extends processing times by 15 to 25 per cent, turning raw materials into waste management.

This Ishikawa-based cause-and-effect analysis prioritizes actions: updating methods and training as a first step, in order to optimize flow and value added per TEU.

c. Environment: Regulatory and external constraints

Infrastructural constraints (storage capacity at 75% capacity, narrow quays) and congested shipping lanes (inadequate depth for large container ships) create physical bottlenecks. Disruptions are exacerbated by environmental factors (such as dust from the Sahara or marine humidity that corrodes equipment) and external factors (such as customs delays or competition between freight forwarders). This structural configuration requires limited optimization, where every square metre and minute is crucial to managing the increase in traffic without resorting to significant investment.

d. Equipment: Under-resourcing and technological obsolescence

The terminal's equipment, such as reach stackers and forklifts, suffers from repeated breakdowns due to inadequate preventive maintenance and excessive workloads. This leads to prolonged periods of downtime (accounting for up to 20–30% of cycles), congestion during traffic flows and a reduced handling rate (below global standards of 25 to 30 movements per hour per piece of equipment). The economic impact is immediate: additional repair costs and productivity losses are estimated at several twenty-foot equivalent units (TEUs) not handled each day.

e. Manpower: Staffing constraints and underutilization

Staff lack specific training in container handling and port logistics procedures, a situation exacerbated by a chronic staff shortage during peak hours (when several ships arrive at the same

time). Cooperation between the various teams (stevedores, customs officers, freight forwarders) leaves much to be desired, leading to misplacement errors and accumulated delays. The result: a proliferation of unnecessary actions (accounting for up to 50% of tasks) and a high staff turnover rate, exacerbating human resource issues in a chain where efficiency depends on synchronization.

3.2 Current process:

a. A chain with multiple bottlenecks:

At the Oran terminal, 90% of containers follow a circuitous and inefficient route, whilst only 10% benefit from a direct 'green' route free of checks. Unloading by crane from the ship to the quay (40 containers per rotation, maximum 6-day turnaround), followed by transfer using a reach stacker (RS) to a temporary storage area. Stacking is then carried out by stacking 5 blocks using an RS or an internal transport truck (CTI), with a buffer period of approximately 1 day. Further movement by forklift truck (FT) to the scanner/weighing point, followed by a ground inspection which requires unloading/reloading by FT before returning to storage. Ultimately, delivery is completed with transport by forklift to the delivery lorry (DL) and an exit scan.

This supply chain generates considerable losses, leading to congestion and additional logistics costs **(Table 2)**.

Table 2: Port operational chain and economic losses

Phase	Equipment	Key time	Economic losses
Unloading	Crane + RS	6 days / vessel	Vessel demurrage
Buffer/Storage	RS/CTI/CG	+1 day	Excessive free storage
Inspection (90%)	CTI/CG	Multiple lifts	+50% fuel/wear
Delivery	CG/CL	Mixed flows	Customer delays (penalties)

Source: Data collected via a survey of EPO managers

b. Capacity: Static and dynamic assessment

According to EPO internal data, actual traffic in 2023 peaked in September with 14 110 TEUs unloaded (with a peak factor of 1,36), representing a 75% utilization rate and an average dwell time of 10 days, resulting in an annual dynamic capacity of 452 896 TEUs. If processes are not optimized, imminent congestion threatens the terminal, hindering the expansion of trade with Algeria, Europe and sub-Saharan Africa **(Table 3)**.

Table 3: Container traffic at the Oran terminal in 2023

Months	Landings	Shipments
Jan–Apr	10710 / 8840 / 9180 / 9 350	6440 / 9360 / 10250 / 8470
May–August	10540 / 8903 / 8891 / 11 050	9520 / 10980 / 6230 / 9270
Sept–Dec	14110 / 12920 / 9520 /	12710 / 13330 / 11290 /

	10880	12286
Total imports	**~ 250 000**	-

Source: Data collected through a survey of EPO officials

c. Economic issue reformulated:

Faced with a growing workload caused by prolonged inspections, high costs and mixed cargo flows, the main challenge is: how can procedures at the Oran container terminal be reorganized to reduce processing times by two-thirds, cut equipment requirements by 60–80% and triple dynamic capacity, with the aim of bringing its performance into line with that of global hubs?

3.3 Solutions and optimization: Logistical and economic innovation:

The proposed solution is based on a complete restructuring of the container management process. In particular, it aims to introduce partial container screening using scanners, which helps to reduce the number of physical inspections. Furthermore, separating the flows of lorries and handling equipment eliminates interference and improves safety. The new system also aims to minimize intermediate stages by prioritizing direct transfers between different zones.

The quantitative comparative analysis covers 250,000 TEUs imported in 2023, 90% of which follow the standard process (1 operation = 1 complete loading/unloading). It compares the current procedure with the optimized one, demonstrating significant benefits in terms of productivity.

a. The current system:

The existing system generates a total of 1 237 501 movements (approximately 5 per container): reach stackers (RS) perform 264 706 operations (from ZQ to the buffer zone ZT, then from ZT to the CTI), forklift trucks (CG) account for 708 089 handling operations (multiple transfers + 25% sorting = 66 177 additional TEUs), and internal transport trucks (CTI) carry out 264 706 internal journeys. These back-and-forth processes (storage → inspection → return) generate significant waste, with restricted rhythms and periods of inactivity.

b. The optimized system:

The proposed optimized solution is based on a general streamlining of the container handling procedure at the container terminal in the port of Oran. Its main objective is to minimize unnecessary movements, optimize logistics flows and increase operational efficiency. The new model, in contrast to the original system which involved numerous intermediate steps, favors direct routes, thereby reducing unnecessary handling and time losses.

In terms of unloading and storage, the optimization aims to ensure that containers are transferred almost directly from the quay to the storage area using stackers, thereby eliminating the need to systematically use intermediate equipment such as internal transfer trucks. This restructuring helps to significantly reduce the volume of movements whilst optimizing the speed of operations. Furthermore, improved organization of storage areas and the separation of flows according to container status help to minimize disruption and unnecessary reorganization **(Table 4)**.

Table 4: Calculation of movements in the optimized process

	Optimized process	
	Mouvements	**Values (Boxes)**

		Formula	Result
Operations by RS	CL to ZVsol	(V*90%) * 9%	**132 353**
	ZVsol to CL	(V*90%) * 9%	**132 353**
	Total	**23 824**	
Transactions by CG	ZQ to ZS	V* 90%	**132 353**
	ZS to CL	V* 90%	**132 353**
	Sorting factor	25%	
	Number of Sortings	VTR * 25%	**33 088**
	Total	**297 794**	

Source: Results of the empirical optimization study

The introduction of partial inspection using a scanner has enabled a thorough review of the inspection process, which was identified as the main bottleneck. Most containers are thus checked quickly without requiring a systematic physical inspection, whilst only a small fraction undergoes a thorough check, either on the ground or directly on the lorry. This method helps to significantly reduce inspection times and speed up the movement of containers.

Finally, the upgraded system optimizes delivery by enabling containers to be released quickly once they have been checked, whilst ensuring improved flow management between the various stakeholders. This overall restructuring leads to reduced equipment requirements, lower operating costs and, above all, a significant reduction in container dwell time. Consequently, the terminal's dynamic capacity increases significantly, which improves its overall performance and reduces the risk of congestion **(Table 5)**.

Table 5: Equipment requirements between the current and optimized processes

	CG	RS	CTI
Current Process	30	10	12
Optimized Process	13	2	0

Source: Data collected through a survey of EPO managers

3.4 Economic impacts and recommendations:

The implementation of the optimized system has significant economic implications for the container terminal. Firstly, the reduction in handling operations and the optimization of logistics routes contribute to a significant reduction in operating costs, particularly in terms of energy consumption, machinery maintenance and staffing costs. Furthermore, the reduction in equipment requirements helps to cut costly expenditure, whilst improving utilization rates.

Furthermore, the reduction in container dwell time leads to an increase in the terminal's dynamic capacity, enabling it to handle a greater volume of traffic without requiring a physical expansion of the facilities. This increase in efficiency enhances the port's competitiveness, lowers logistics costs for economic operators and reduces the risk of congestion, which is often a source of additional costs. On a larger scale, these benefits help to optimize the flow of trade and enhance

the attractiveness of the port of Oran within its regional context.

Conclusion:

An examination of the operations of the Oran container port highlights the crucial role of port logistics in the overall efficiency of maritime transport chains and global trade. Today, containerization and flow management are crucial tools for ensuring the efficiency, speed and competitiveness of transactions.

The analysis highlights various structural and organizational constraints that hinder container management, the complexity of operations, the lack of coordination between stakeholders, as well as certain restrictions related to technical and human resources. These issues lead to bottlenecks, prolonged delays and a decline in operational efficiency.

The method employed is based on flow analysis and root cause identification using appropriate tools, leading to the proposal of an improvement plan aimed at simplifying procedures, minimizing redundant tasks and optimizing product tracking. The adoption of solutions such as digitization and the use of modern control technologies appears to be a crucial factor in improving the terminal's efficiency.

The proposed improvements could lead to significant increases in productivity, a reduction in expenditure and better utilization of existing infrastructure, without requiring major investment in physical development. From this perspective, the development of port logistics is essential to improve the competitiveness of the port of Oran and facilitate its integration into global logistics networks. Future studies could enrich the analysis by incorporating the simulation tools described and real-time intelligent flow management systems.

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