The role of 4.0 industry on the digital and ecological transformation of the seaport ecosystem.
A case study of the Algerian Port Community System (APCS)

دور صناعة 4.0 في التحول الرقمي و الايكولوجي لبيئة أعمال الموانئ البحرية

دراسة حالة: المنصة الرقمية الجزائرية.

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Abstract:

The objective of this paper is to show how Industry 4.0 may help digital transformation occur by transforming ports from ecosystems to smart, sustainable ports. This paper relies on a study of the Algerian port community system (APCS). The results of the study reveals that very positive outcomes were achieved through the adoption of technologies; for example; reducing the period of passage of goods through the ports by five days. This brings revenues equivalent to 13.15 million dollars per year, and the digitization of 75% of documents along ports supply chain. However, for Algerian ports, the digital transformation and their exposure to bureaucratic obstacles and opposition from government institutions hindered good progress. Have the economic and political will by all the port logistics stakeholders. Also, the building of partnerships with specialized competencies are the keys to the success of the smart and sustainable ports project in Algeria.

Key words: 4.0 Industry, seaport community system, sustainable development, Smart port, Algeria.

الملخص:

مساهمة الصناعة 4.0 في احداث التحول الرقمي بالانتقال من نظام بيئي للموانئ الى موانئ ذكية ومستدامة، هو الهدف الذي أسس عليه هذا المقال. اعتمدنا على دراسة النظام البيئي للموانئ الجزائرية، وأفضت نتائج الدراسة الى الكشف عن بلوغ نتائج جد إيجابية من خلال تقليص مدة مرور السلع عبر الموانئ بخمسة أيام مما يعود بعوائد تعادل 13.15 مليون دولار في السنة، إضافة الى رقمنة 75% من الوثائق الضرورية على مستوى سلسلة الامداية للموانئ الجزائرية، غير أن التحول الرقمي للموانئ الجزائرية وبتعرضه الى عوائق بيروقراطية ومعارضة من طرق هيئات حكومية عرقل من السير الحسن. التحلي بالإرادة الاقتصادية والسياسية من طرف جميع الأطراف المشاركة واللجوء الى بناء شراكات مع كفاءات متخصصة يمثل مفتاح نجاح مشروع الموانئ الذكية و المستدامة بالجزائر.

الكلمات المفتاحية: الصناعة 4.0، نظام بيئي للموانئ البحرية، الموانئ الذكية، التنمية المستدامة، الجزائر.

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1. INTRODUCTION

Seaports are the pillars of international supply chains, and transport networks. By carrying out a set of activities and operations, they are fundamental for supply chains. Their role starts with the reception of containers at the harbor, then at the quay, in order to unload and store them at the terminals. Then, if necessary, after the settlement of customs procedures and control, they ensure the loading of containers into transport trucks, in order to deliver them to customers.

All of these operations ensure the fluidity of the goods and information along the supply chain. On the other hand the multiplication of the tasks causes harmful effects on the environment, through the emission of gases, air and noise pollution.

Several economic actors collaborate in order to increase performance and improve port competitiveness, by adopting an ecological green vision and a sustainable economic dimension.

The global experiences of leading ports affirm that 4.0 industry has largely contributed to the development of an efficient, competitive, and sustainable seaports ecosystem.

This article aims to understand how 4.0 Industry has contributed to the digital and ecological transformation of the port ecosystem in order to ensure competitive and sustainable seaports.

The study thus investigates the following research question:

What role does 4.0 industry play on the digital and ecological transformation of the seaport ecosystem?

In order to answer our research question, we start with a literature review of the 4.0 industry. Then we will show the system adopted by seaports, known as "PCS: Port Community System". PCS is powered by 4.0 industry technologies, which allow for the creation of smart seaports. In the third section of this research paper, we shall address these topics. We end our literature review with the link between the 4.0 industry and the development of a sustainable ecosystem at the seaport level.

This research uses a single case study to describe the Algerian port community system (APCS), and analyses the prospects for the creation of a sustainable ecosystem at the level of the Algerian seaports. We use an interview guide that can help us collect information from the managers and engineers we meet on the progress of the study. In addition, we will analyze the secondary data provided by APCS.

2. Literature review: from PCS to sustainable smart seaport, what is the contribution of 4.0 industry?

In order to illustrate how the 4.0 industry helps turn the port community system into a sustainable smart port We have to address the genesis of industry 4.0 and the concept's development. This includes highlighting the various tools and technologies that have emerged with the 4.0 the industry revolution.

Sea ports represent an important unit in the supply chain. For this reason, we explain through the literature review the extension and impact of Industry 4.0 on supply chain management, specifically on sea ports.

Consequently, revealing the transformation of ports from inter-organisational systems to smart ports occupies an important place in our subject. The integration of sustainable dimensions in smart ports represents our last object to study in the literature review. This way, we can theoretically explain how Industry 4.0 contributes to transforming the port community system into a sustainable smart port.

2.1. 4.0 industry and the emergence of 4.0 supply chain

4.0 Industry (I4.0) is also known as "industry 4.0 platform" in Germany, "industry of the future" in France, "Japan Revitalization Strategy" in Japan, and, in the United States, "Advanced Manufacturing Industry 4.0 (I4.0) from 2011. The term Industry 4.0 appeared in Germany for the first time, and the Association of German Machinery and Equipment Manufacturers revealed it to the public during the Hannover Fair. This term, which is similar to a slogan, means and symbolizes the entry of the industry into its fourth revolution. (1)

The German federal government supported the idea by announcing that I4.0 will be an integral part of its "High-Tech Strategy 2020 for Germany" initiative, aiming at technological innovation leadership. The subsequently formed "Industry 4.0 Working Group", published in April 2013 the first recommendations for implementation of the 4.0 concept. (Kagermann et al., 2013, p. 77). They described their vision of I4.0 as follows: "In the future, businesses will establish global networks that incorporate their machinery, warehousing systems and production facilities in the shape of Cyber-Physical Systems (CPS). In the manufacturing environment, these Cyber-Physical Systems comprise smart machines, storage systems and production facilities capable of autonomously exchange information, trigger actions and control each other independently(2)

Therefore, the I4.0 concept was linked to the adoption of information technologies in order to optimize the value chain at the level of industries .On the other hand, between the adoption of technology and the optimization of the value chain, the managerial process reveals the importance of business factors in the definition of I4.0. In this context, a review of the literature conducted by Polish researchers with the aim of arriving at a consistent definition of I4.0 that we summarize in the following table through the two factors that define I4.0.

Table1. Industry 4.0 definition scheme.

concept	Industry 4.0	
Motivation	Optimization of production cost while leveraging customization resulting from individual changes in customer needs	
Enablers Drivers	New technologies and solutions	
Source	German government initiative presented at Hannover Messe 2011.	
Two Integral factors groups that constitute the concept	Technological factors	Business factors
	CPS as connection between physical and virtual world	Value chain integration as result of real time communication capabilities, data collection and processing and the use of intelligence decision support systems.
	Smart Factory as a place where intelligent/smart production makes it possible to meet the personalized expectations of customers	New Business Models as a response to personalized customer needs and focus on company activities on operations in digital business environment
	Internet of things (IoT) as a network enabling communication between objects in real and digital world	Smart product as an offer generation higher added value through use of new data access and analysis opportunities.
		Customer's position- a personalized approach to customers as partners in value creation process.

According to this framework they define the I4.0 as organizational and technological changes along with value chains integration and new business models development that are driven by customer needs and mass customization requirements; It is enabled by innovative technologies, connectivity and IT integration.

But industry 4.0 does not remain confined to the walls of the factory; it extends to all the actors and operations. contributing to create a more global value chain at the level of the supply chain.

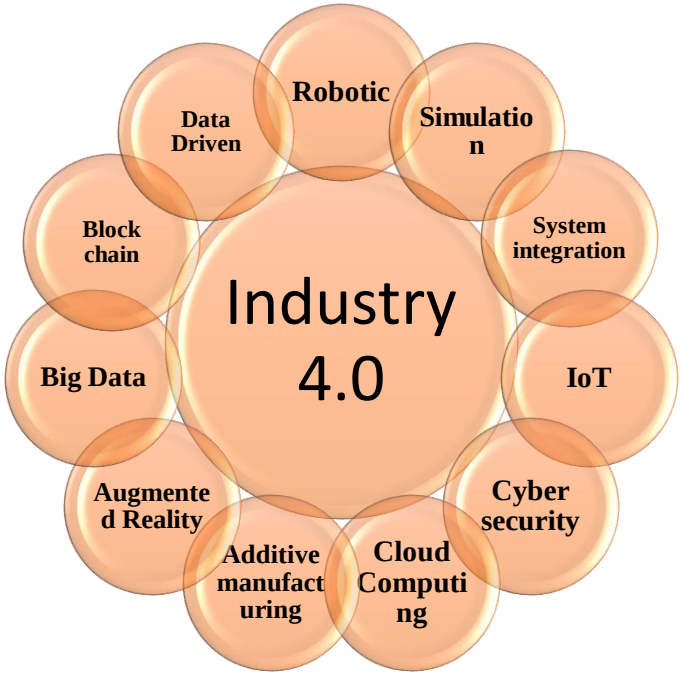
Source: *Katarzyna Nosalska, Zbigniew Michał Piątek, Grzegorz Mazurek and Robert Rządca,(2020),* ***Industry 4.0: coherent definition framework with technological and organizational interdependencies****, Journal of Manufacturing Technology Management, Akademia Leona Kozminskiego, Warsaw, Poland, Vol. 31 No. 5, , P :12.*

The extension of the application of industry 4.0 to invent the supply chain 4.0, appears as a new ecosystem of supply chain partners. Several studies define the concept of supply chain 4.0, and all share one point in common that it is an "*evolution of supply chain operations thanks to the advanced digital technology* »[(3)]

At this level of reflection, two questions arise: what technology is integrated in the supply chain, and which is inspired by I4.0? How has this technology affected the managerial process at the supply chain level?

The I 4.0 has offered several technologies to create value for supply chains, as the following figure shows (Fig N.1).

Fig.1. 4.0 technologies integrated into supply chains.



Source: *adapted by researchers from Khadmi Mubarok, Redefining Industry 4.0 and Its Enabling Technologies, Journal of Physics: Conference Series, 1569 (2020), P:05.*

Carlos Andrés Tavera Romero , Diego F. Castro , Jesús Hamilton Ortiz , Osamah Ibrahim Khalaf , and Miguel A. Vargas , (2021), Synergy between Circular Economy and Industry 4.0:a literature review, sustainability , 13, 433, P:03.

The most famous 4.0 technologies intended to automate the supply chain are big data, industrial automation (robotics), simulations, integration systems, the internet of things (IoT), cyber- security, cloud computing, additive manufacturing, and augmented reality, Block chain and data driven as the main comprehensive factors of technological work aimed at continuous improvement.

The introduction of these technologies has transformed supply chain processes. Garay-Rondero et al. (2020) explained this transformation by defining the digital supply chain as a proactively executable platform (or an ecosystem-driven supply chain) on which all companies can collect and analyze real-time data inside and outside the supply chain using information technology, communications, and new analytical techniques.(4) which allows the creation of a unique digital ecosystem with value chain partners(Di Nardo, 2020).

For Moore (1993, 1996) the success of innovative firms depends on their ability to mobilize resources owned by other organizations such as partners, suppliers or customers.(5)

The sharing of resources (material or informational) between the partners of the supply chain results in the creation of an ecosystem.

Iansiti& Levien (2002, 2004a, 2004b) and Iansiti & Lakhani (2017), define ecosystems as a large number of loosely interconnected participants which depend on each other for their mutual effectiveness and survival. In the same context, Moore sees such ecosystems evolving from one dispersed group of organizations to a more structured community.(6)

The integration of 4.0 technologies does not serve the purpose of using real-time data, but one of the goals of the digital supply chain is sustainability. In a report written with the WHU Otto Beisheim School of Management, A.T. Kearney (2015) presented the ecological and sustainable dimension of the digitization of the supply chain in order to minimize the waste that occurs in the environment due to fluctuations and risks associated with high demand.(7)

2.2 Background: From PCS to Smart ports.

For more than thirty years, the seaports in the world have been convinced that the objectives of performance, competitiveness, and sustainability depend on the construction of a structured community, or, in other words, on creating links between all the actors, links that contribute to the fluidity of the goods and information. The story began with the installation of exchange systems between actor's seaports, known as the Port Community System. It is defined as an inter-organizational system used for enabling commercial services and providing information exchange between the port to their customers and a variety of stakeholders, such as forwarders, carriers, importers, exporters, customs, among others (IPCSA, 2015; Tsamboulas et al., 2013; Long, 2009).(8)

Port community system is a form of single window for trade, a tool to exchange messages in port environment, having a commercial and logistic nature, that has B2B (Business to Business) character.(9), in return for the existence of a system which provides local level information about the vessel to the authorities on a port level, that has B2G (Business to Government) character, this one named **Port Single Window (PSW)**.

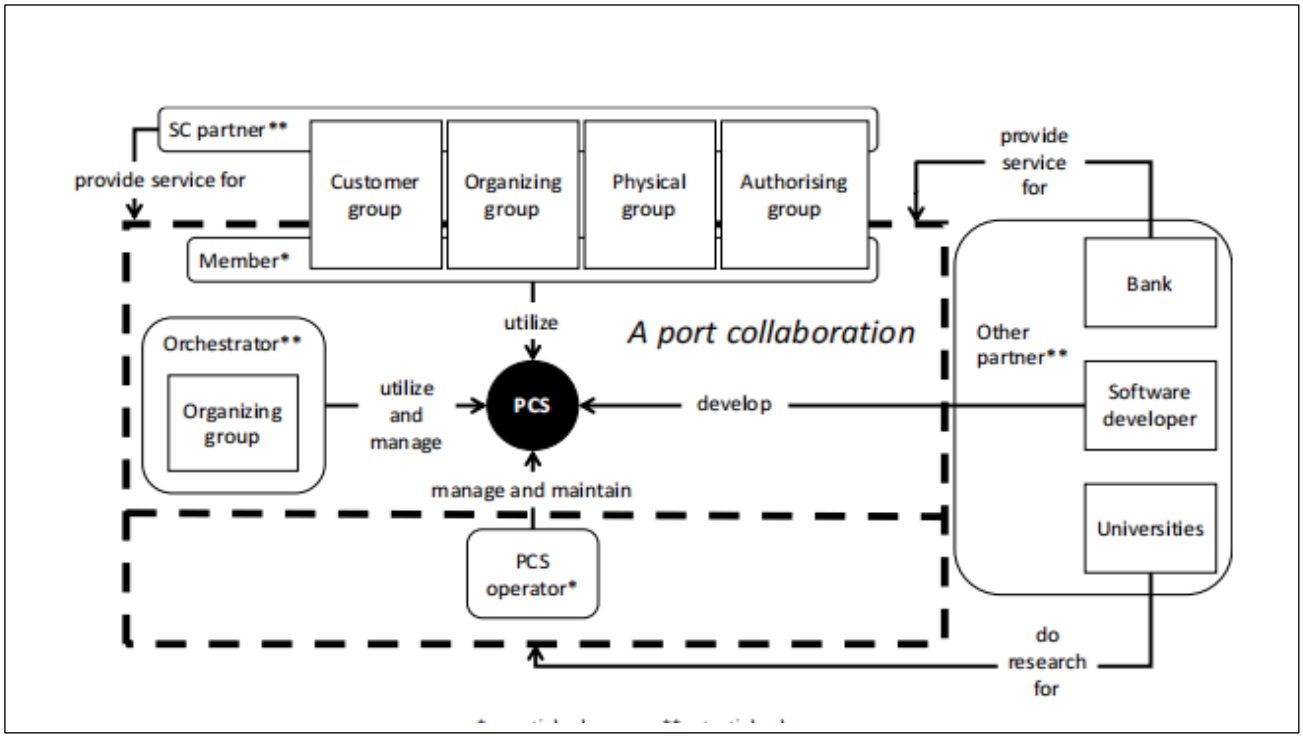
On the other hand, bringing all users together under the same system does not materialize except with the automatization and digitalization, in other words with the integration of technology. Industry 4.0 has played an important role in guiding managerial processes and the digital transformation of seaports. This is the reason why The European Port Community System Association (2011) defines a PCS as a neutral and open electronic platform enabling intelligent and secure exchange of information between public and private stakeholders in order to improve the efficiency and competitive positions of the seaport communities. A Port Community System optimizes, manages and automatizes logistics-efficient processes through a single submission of data, connecting transport and logistics chains (10)

By analyzing the two previous definitions, we find that PCS has two dimensions: a technological dimension and the relationship with inter-organizational management between actor's seaports.

In order to understand the functioning of the PCS, it is necessary to identify the actors who weave this community and their roles.

According to previous studies (Wagenaar in van Baalen et al. (2009), Chandra and Hillegersberg (2015), Dissa R. Chandra and Jos van Hillegersberg in 2017 proposed a classification of seaport partners according to the roles granted. The figure N2 below describes this classification.

Fig.2: Roles and example of organizations in a port collaboration



Source: *Dissa R. Chandra, Jos van Hillegersberg, (2018),* ***Governance of inter-organizational systems: a longitudinal case study of Rotterdam's Port Community System****, International Journal of Information Systems and Project Management, Vol. 6, No. 2, P: 50.*

As reported by these researches, the actor who play an essential role are the PCS operators. The PCS operator is responsible for managing and maintaining the PCS according to Service Level Agreements (SLAs) with the members. On the other hand, the members can be essential or potential, as stated in their degrees of collaboration and investment in the PCS, they are defined by Wagenaar in van Baalen and al. (2009) as entities that are the members of a port collaboration and can be involved in the operational, tactical, or strategic activities of the collaboration. The members adopt the shared services to support their SC activities in the port environment. They are distinguished through four groups: the customer group, the organizing group, the physical group, and the authority group. The table below (Table N02) illustrates with examples the organizations that make up each group.

Table2. Potential members of port collaborations.

Group based on the organizations' activities in the SC arrangement	Examples of organizations
Customer group	Shipper; Consignee
Organizing group	Forwarder (merchant haulage); Shipping line agent (carrier haulage); Logistics service provider (4PL)
Physical group	Sea terminal operator; Shipping line/sea carrier; Pre- or On-carrier: carrier inland transport, i.e., barge operator, rail operator, road carrier; Inland terminal operator; Logistics service provider (3PL); Empty container depot operator
Authorizing group	Customs; Port authorities; Seaport police; River police; Inspection authorities

Source: *Ibid, p: 49.*

However, the organization which plays the potential roles are designed by:

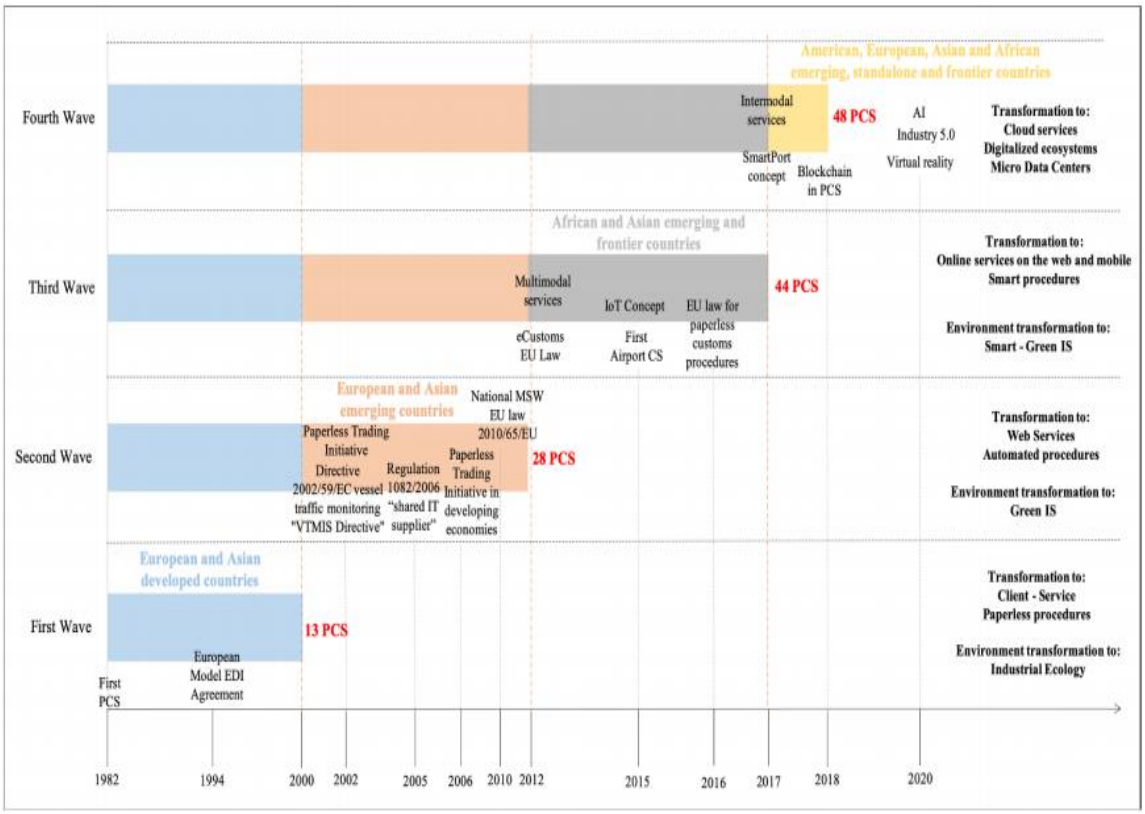
- ✓ Orchestrator: is a company that coordinates the SC activities inside the port collaboration;
- ✓ Other partner: is an organization that supports port collaborations besides the SC partner and the PCS operator;
- ✓ SC partner: Outside port, collaborations there are organizations, which perform SC activities related to the collaborations. These organizations are not members of port collaborations, but may get access to the shared system. However, their benefits are not a priority for the collaborations. Consequently, these organizations will not be expected to pay fees for using the system.

The performance of seaports and competitiveness are not the only objectives of the reconciliation between technology and the management of seaports. Sustainability of seaports ecosystem has been a primary goal since the first genesis of the PCS.

2.3. The Contribution of 4.0 industry for sustainable ecosystem's seaport

The literature review confirms that PCS aims to ensure a performance seaports ecosystem. Nevertheless, there does not exist a universal model or structure for PCS, but the countries built PCS according to the objectives, the integrated technology, and the culture of the stakeholders. The study by Adriana Moros-Daza and al. in 2020, made an inventory of the different models of PCS in the world. Four waves of PCS were unveiled; Fig.3 shows the evolution of the PCS framework.

Fig.3. PCS framework evolution.



Source: *Adriana Moros-Daza , René Amaya-Mier , Carlos Paternina-Arboleda, Op-cit, P:28.*

Since the birth of the first PCS, the most basic function granted to the latter is the sharing of information between the various partners in the logistics and port chain. On the other hand, in the first generation of PCS, the sharing of information was limited between the customer and the port services through EDI technology (Electronic Data Interchange) in order to create paperless procedures and therefore **protect the environment.**

The second generation of PCS worked on the automation of all operations, sharing IT suppliers and the integration of web services to move towards zero paper and develop a **green system.**

In the third generation of PCS has aimed to initiate the adoption of artificial intelligence tools, starting with the integration of the IoT concept and to involve the consumer in the digitalization process. This phase summarized the transition to multimodal sharing of information, thanks to the use of online services but also mobile smart procedures with mobile applications. **Smart green information systems** were the fruit of the move towards digitalization.

The fourth generation reflects the recent development of PCS and includes the industry 4.0 and industry 5.0 tools, as cloud services, blockchain, virtual reality, which become the most important factors in the historical development of smart ports. This phase illustrates a true digital transformation for seaports, triggered by the 4.0 revolution. About the inter-organizational process, the intermodal service has to occupy the most suitable mode with the objective traces; intermodal services to optimize time and cost, and to enrich the legacy PCS with a new added value service (Zlatanova and Beetz, 2012; Zuidwijk, 2015)[(11)]

Each period is featured by the introduction of directives to law adoptions. It should be noted that for each port region, a PCS can take different forms in response to various physical, modal, law, and operational characteristics (Tsamboulas, Moraiti, & Lekka, 2012).[(12)]

In terms of technology, the last seaports reaching a mature stage, with smartport exploration, are defined as ports which use IoT-technology to link all devices together Yang and al. (2018, p. 34), Delenclos and al. (2018) defines smart ports as digital-based multistakeholder systems.[(13)] Nowadays, seaports are working on the integration of sound sensors, vibration sensors, humidity sensors, geolocation sensors, etc. at the container level by innovating smart containers or which is named by the future of seaports.

The smart port demonstrates increasing interest in permanent enhancement of all business solutions. The main idea is to combine not only economic but also ecological aspects dealing with issues with traffic/goods flows and infrastructure. [(14)]

To understand the relationship between those technologies (smartport) and sustainability in logistics operations (green operation port), it should be to Show which technology is best for which application and how it affects the environment at seaports.

Appendice.1 summarize the most important 4.0 technologies adopted by smart ports and their impact on their environment.

4.0 Industry has profoundly contributed to the evolution of seaports from a system to a smart port. This contribution has supported ports to become more efficient, more competitive, and more environmentally friendly. IoT, artificial intelligence, and drones have largely helped to detect polluting gases emitted into the air and water by ships, noises caused by traffic, false circuits during the movement of means of transport, and dangerous vibrations during the loading and unloading of

the goods. On the other hand, cloud computing, big data, and block chain are approved for their usefulness in giving a secure response in real time, allowing people to act at the right time before any act can affect the environment. In return, reality increases, and robotics facilitates the task of human beings and protects them from all risks, thereby ensuring lasting protection. Thanks to renewable energies, seaports can redirect the use of resources in an optimal way, by eliminating bad ones and exploiting useful ones, to ensure the sustainability of port activity without affecting the environment and protecting the environment life of future generations.

3.Methodology

This research aims to explain how industry 4.0 contributed to the transformation of port community systems into smart and sustainable ports. As we select the Algerian context, the case study is the most appropriate methodological approach. Our practical applications, Algerian Port Community System. The documentation sources supplied by the APCS office don't seem to be enough to address our study issue, so we conducted interviews with office and IT managers, utilizing an interview guide.

4. Case study: Algeria Port Community System «APCS», a model of digital transformation of port ecosystem

4.1. Development of Algeria port community system.

The Algerian Port Community System, also known as "APCS," is a joint stock company that was established on March 23, 2021 as an economic subsidiary of the "SERPORT" Port Services Group. Its share capital is one hundred and fifty thousand Dinars (150,000,000 DA).

This digital platform founded at first time with the aim of dematerializing the process of port logistics. Then, the strategic position it occupies in the port environment has widened the strategic vision towards strategic objectives and other operational ones, which can be summarized according to the following table.

Table3. Strategic and operational objectives of APCS

Strategic objectives	Operational objectives
✓ Find a unified harbour ecosystem; ✓ eliminate asymmetric information; ✓ Improve Algerian ports' performance and competitiveness.	✓ Improve transit processes in ports ✓ Increase the performance of services provided to customers ✓ Increase processing capacity in ports ✓ Ensure real-time physical and administrative monitoring of goods ✓ Exchange information confidentially and securely

Source: *https://apcs.dz/# April 25, 2023.*

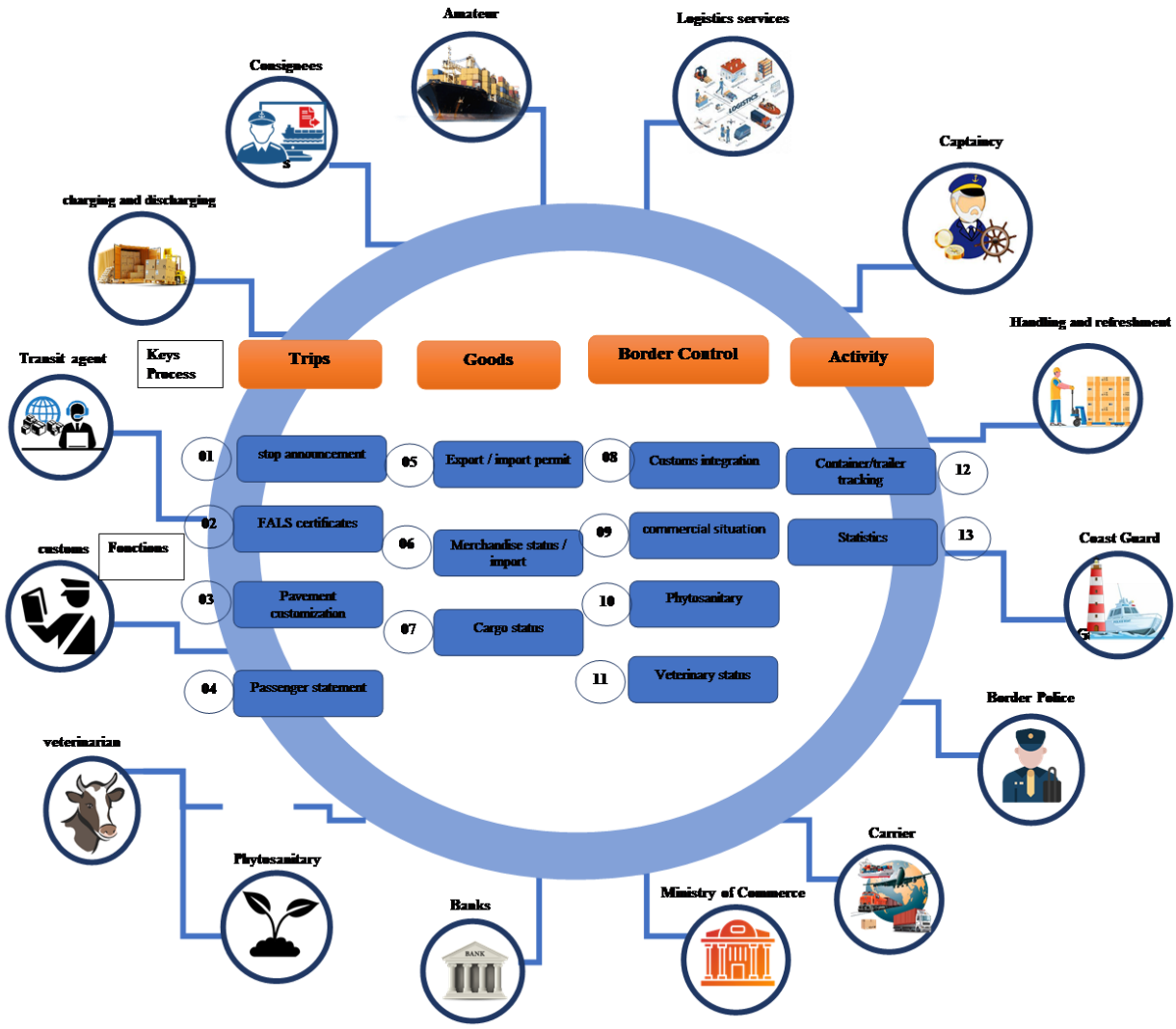
Improving the performance and competitiveness of the ports requires the unification of information "hub of data", the reduction of costs, the reduction of delays, the reduction of useless carrier

rotations, and the elimination of demurrage. Achieving these objectives requires a united and global vision among all port actors, but also modern technological infrastructure.

4.2. The ecosystem's Algerian port.

The best way to describe the partners of the ecosystem is to schematize it; figure.4.presents the different stakeholders.

Fig.4. Algerian ports ecosystem, 2023.



Source : *APCS public relation office, Algies, 02 May 2023.*

It is clear from the figure, that the digital platform plays the role of a one-stop "Single Window" between the various business environment partners. They are represented by government agencies: from the Ministry of Trade and Export Promotion, the Ministry of Agriculture, the General Directorate of National Security, customs services, coast guards, and banks[(15)], where official business agreements concluded with APCS. A number of economic agents, including commodity carriers, transit agents, and freight forwarders, were integrated by training them to use the platform,

in addition to port management representatives from the port command, ship-owners, and logistic services. All these partners unite in order to ensure the tracking of containers and trailers, while providing data, monitoring, declaration of goods, and ensuring the progress of the journey of goods along the supply chain.On the other hand, the use of the platform requires knowledge of the modules constituting the platform and the steps to follow in order to finalize the mission of the partners concerned. The reason why the administrative council of the APCS, as well as the 30 agents mobilized to launch, manage and promote the digital system of the port community have engaged in a face-to-face training process on behalf of the consignees, warehouseman's, freight forwarders, customs staff, border police officials from the Ministry of Commerce, and all stakeholders.

The result of the training offered concluded with very satisfactory results. The following table summarizes the number of users of the platforms according to each profile.

Table 4. Users per profile APCS 2022.

Profile Users	November 2022	Total number
Users ports APCS	97	445
consignees	88	658
side guard	04	36
maritime border police	28	65

Source: *Annual report, APCS, 2022, P: 30.*

In less than a year since the launch of the training, APCS has reached percentages of between 13 percent and 43 percent for the exploitation of the platform by different categories of users. This result represents a feat for the APCS.

Being the single window open to all partners at the same time requires advanced technology, we present in the following point the technologies adopted by APCS

4.3. Technological framework infrastructure of APCS.

The following table outlines the different 4.0 technologies currently operated by APCS, and those that are an ongoing project, as well as the 4.0 technologies that represent APCS's prospects.

Table 5. Technology Framework APCS.

Technology category	Name	Currently adopted	A project in progress	Among the prospects of the APCS in the far future.
automatisation	**/**	**No**	**No**	**Yes**
Internet of things	**/**		**No**	**Yes**
blockchain		**Yes**	**No**	**Yes**
Big data	**Apache Spark**	**Yes**	**Yes**	**Yes**
Robotice	**/**	**No**	**No**	**No**
Artificial intelligence	**PyTorch Keras**	**Yes**	**No**	**Yes**
Cloud	**/**	**/**	**/**	**/**
Augmented reality	**OpenCV Vuforia**	**Yes**	**Yes**	**Yes**
Renewable energies	**/**	**No**	**No**	**Yes**
Drone	**/**	**No**	**No**	**Yes**
Others	**/**	**/**	**/**	**/**

Source: *interview with APCS engineers, Algiers, April 2023.*

APCS was launched with an electronic data management (EDM) system and an electronic courier management (ECM) system to dematerialize the port logistics process. On the other hand, the prospects of APCE towards a digital transformation of the port ecosystem, has widened the scope of technological investment towards 4.0 technology, starting with the installation of a main data center at the level of the port of Algiers, counting in the future to establish another security data center. In order to ensure secure management of the database, APCS has used big data technology (Apach and Spark) to strengthen data security by integrating blockchain technology. Artificial intelligence technology has taken a place in APCS (PyTorch Keras) as well as augmented reality. In the two years since its establishment, APCS has been able to incorporate advanced technologies. The latter affirmed the reconciliation between the good will and the competence of the administrative and engineering staff. The engineers reveal that the orientation toward the smart port concept is one of the main objectives of APCS. That is why APCS plans to automate all port operations and adopt IoT to move to smart container management. With the aim of consolidating a sustainable ecosystem, renewable energy technology is among the long-term prospects of APCS. The control and monitoring of all logistics operations in complete safety is one of the most important port activities, which is why engineers are thinking about the long-term use of drones.

4.4. The working process of APCS

As already mentioned, the APCS board and its engineering and administrative staff have been able to bring together different users in the same community, the port community, under one roof, called APCS, by creating a digitized port ecosystem. APCS ensures interaction between stakeholders as single window. Appendice.2 show the different interactions between APCS users, summarize the operating process.

The birth of APCS did not change the traditional logistics process for the processing of goods. On the contrary, it is working on its digitalization by intervening on the following modules:

- ✓ Management of ship announcements;

- ✓ Dock management;
- ✓ Merchandise management: Manifest, Quay view, delivery Order, management visits, delivery order manutention, delivery order customs, report delivery;
- ✓ Merchandise tracking;
- ✓ Dashboard and statistics.

As part of the traditional logistics process, the customer (importer or exporter) presents the import or export file to a freight forwarder, in order to have delivery form. Freight forwarders contact the customs department, the port company, and the quality control services if necessary. The freight forwarder begins with the revision of the file (import-export), and then he addresses the customs in order to declare the file on the SIGAD (computer system for the management and control of goods clearance operations) system. Once the file is valid, he brings back the paper version of the file to submit it to a customs officer, who then begins the review of the necessary documents in the file. If all the documents in the file are available, he transfers the file to the main inspector of the services, who validates the confirmation of the file, and he in turn transfers the file to the principal inspector of commercial operations. To conclude the control operation, the Principal Inspector of Commercial Operations appoints a customs agent, whose role is to visit the container on the premises and ensure confirmation between the declaration and the goods actually available. Then, the freight forwarder of the goods pays the duties and taxes at the level of the fund. With the payment slip, he can obtain the exit slip of the goods. At this time, the port services intervene to ensure the means and tools for loading and unloading, and the transport partner accesses the port in order to transport the goods to the end customer[(16)]. (Appendice.3).

Consequently, the intervention of the APCS begins from the end of the port logistics chain, integrating all activities: the harbormaster's office, handling, logistics, container terminal, and announcement. The main purpose is to ensure the exchange of messages through the APCS platform between the stakeholders who perform these tasks: amateurs, consignees (shipping agents), freight forwarders, customs, phytosanitary-trade control services, and carriers (trucks, rails). The exchange of messages and e-mails replaces all papers with files scanned and deposited on the APCS platform, of which each party or partner has a module to access and deposit these scanned documents. Once sent as an e-mail, the electronic exchange of messages between the different parties is triggered as notifications in order to proceed to the next stage, until the delivery of the goods to the customers at the other end of the chain. Appendice.2 schematizes the process of the electronic exchange of messages and letters between the various stakeholders.

4.5. APCS performance and their impact on the sustainable environment

Nowadays, the integration of port stakeholders is done gradually. Despite the administrative obstacles, which represent a major challenge for APCS, two modules are united under the roof of the APCS platform: management of ship announcements and management of quays. On the other hand, the opposition of the customs services to the APCS project has somehow blocked the management of the goods, which represents the last module of the platform.

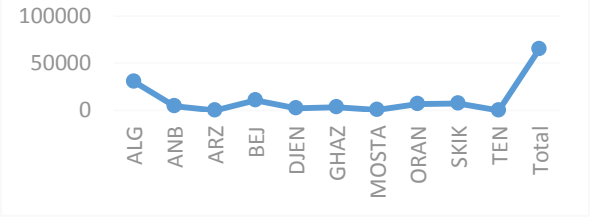
Between the good will of the APCS and the institutional obstacles, the fruits of digitalization are beginning to bear fruit. After the launch of the platform on July 1, 2021, until November 1, 2022, APCS began to record deliveries in the platform. The table below figures the flow of goods in the APCS platform.

Table.6: deliveries per month (CEN)* published in the APCS platform (July 01, 2021-December, 2021)

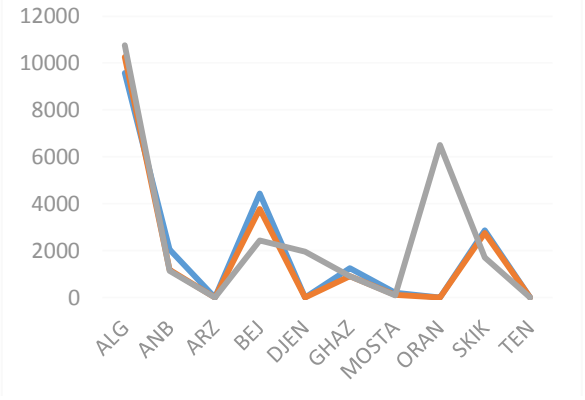
Per Month	ALG	ANB	ARZ	BEJ	DJEN	GHAZ	MOSTA	ORAN	SKIK	TEN	Total
October	9582	2061	1	4440	0	1247	201	0	2876	0	20408
November	10258	1185	0	3772	0	911	117	0	2755	0	18998
December	10761	1136	0	2437	1961	915	83	6502	1712	0	25507
Total	30601	4382	1	10649	1961	3073	401	6502	7343	0	64913

Source: *Annual report, APCS, 2021*

Graphic .1.
The presence of Algerian ports on the platform.



Graphic . 2.
Deliveries recorded on the platform according to Algerian ports since July 01, 2021.



Source: *Annual report, APCS, 2021*

After six months of exercise, the results show explicitly that the port of Alger is more present on the platform, followed by the port of Bedjai, and then the port of Skikda. On the other hand, the port of Oran marked its presence massively in December 2021, while the ports of Tenes and Arzew are practically absent. In return, the ports that remain are more lightly integrated.

The flows recorded are close from one month to another for the majority of the ports; on the other hand, all the ports marked a small decline in terms of registration when we compare between the month of October and the two months of November and December, except the port of Algiers.

An analysis carried out by the management of APCS before the year 2021 and the end of the year 2021 affirms that the operation of the platform has made it possible to gain 0.8 days at the harbor level and 05 days of passage in the port, generating significant savings in terms of time and money. APCS analysts estimate an amount of 13.15 million dollars per year as a gain using APCS. The dematerialization of 75% of the documents necessary for the import port process in order to save paper, reducing carrier rotations, and reducing the time of ships at the roadstead have a significant positive impact on the environment by reducing pollution, diffuse gases, and noise. These effects greatly contribute to work in a sustainable ecosystem.

5. Conclusion

4.0 Industry has largely contributed to transforming seaports into smartports. In order to improve the performance and competitiveness of seaports, the latter, like all economic sectors, have integrated computerized solutions such as the exchange of computerized data and the dematerialization of logistics operations. Consequently, the port ecosystem has started to see a certain unification among the stakeholders. Orientation toward digital transformation was the objective of seaports in order to ensure sustainable and efficient management of the port logistics process. 4.0 technologies: big data, cloud, artificial intelligence, automation, the internet of things, blockchain, robotics, renewable energies, drones, etc., represent the main support for:

- ✓ Exchanging data between partners in the port logistics chain in a secure way;
- ✓ Perform logistics operations by saving time, energy, and resources;
- ✓ Monitor all logistics operations, from the arrival of ships at the harbor until the delivery of goods, by controlling movements, vibrations, storage conditions, loading, and unloading using IoT sensors;
- ✓ Unify the stakeholders in port logistics by creating a single window, thus creating a more favorable ecosystem.

The previous achievements have had a considerable impact on the ecological aspect, through the reduction of gases, pollution, and noise.

4.0 technology thus regenerates an efficient and sustainable logistics chain and port ecosystem.

Since March 2021, the port services group SERPORT has created a new subsidiary specialized in the digital management of Algerian ports. The birth of the Algerian port community system has begun since July 1, 2021, to gradually integrate port actors and partners into the platform. After the signing of the protocol agreements and the launch of training on behalf of consignees, freight forwarders, coast guards, and maritime border police, APCS has begun to reap the fruits of its labor, marked mainly by:

- ✓ The operation of APCS by 1044 actors at the supply chain level;
- ✓ recording of 27,138 container delivery through the APCS platform;
- ✓ Reduce the delivery time of containers by five days compared to the years preceding 2021;
- ✓ Save the equivalent of 13.15 million dollars per year during the port's passage in demurrage.

Consequently, these results bring together port logistics players for the management of ships at the roadstead and the management of goods at the quay in the same hub through the electronic management of documents and mail. On the other hand, the resistance of the customs services to the integration of the platform has delayed the introduction of the single window.

It is a necessity for Algeria to materialize the logistic process, not only ports. The Algerian government is supposed to support the APCS project to achieve the objectives of digitalization by eliminating all bureaucratic obstacles and encouraging all government institutions to integrate into the platform.

The realization of this project requires openness to the environment; for this reason, APCS needs to integrate with international associations represented by the global PCS to benefit from the experiences of other countries and consequently accelerate the process of digitalization.

Achieving the establishment of a smart port in Algeria requires computer, management, and legal skills. The openness of APCS to its environment and the search for partners represent a favorable alternative to unblock situations in difficulty.

Building a sustainable and digital port ecosystem requires the collaboration of all economic actors: port services, freight forwarders, government institutions, etc. A communication and awareness program led by APCS is imperative to cultivating good economic and political will.

APCS should adopt the CSR (corporate social responsibility) approach to ensure a sustainable and successful ecosystem.

The creation of a smart port is not the responsibility of APCS alone; rather, it is the duty of all stakeholders.

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Appendice.1. the impact of technology 4.0 on ecosystem seaport.

Technology	Sustainably effects
Internet of Things (IoT)	IoT sensors are used to monitor and control the movement of containers, vehicles, and other equipment, allowing better cargo loading and unloading management and planning. That system reduces queuing time and greenhouse gas (Stank et al., 2019) The use of integrated sensors allows control of air and noise pollution.
Blockchain Big data	Improve the security and transparency of commercial transactions,and improving trust between different actors in the port ecosystem, reduced bureaucratic bottlenecks in transportation , use of resources intelligently, minimizing negative effects on the environment, use data, to learn and solve, problems quickly and optimally, for example, monitoring emissions, monitoring energy consumption, greenhouse gas emissions, analyze Traffic partner etc. (Meudt et al., 2017; Puig, et al., 2017), eliminate wasteful processes
Automation	autonomous operation of equipment and processes. Automation systems can include container cranes, forklifts, and automated conveyors, improving the efficiency and safety of port operations.
Robotics	perform tasks that require precision and strength, such as container handling
Artificial Intelligence	used to improve the efficiency of port processes and decision-making. AI systems can analyze large amounts of data to detect patterns and trends, optimize shipping routes, and improve inventory management.
Cloud computing	Is used to store and process large amounts of data, allowing for better cargo loading and unloading management and planning. Data can be analyzed in real-time to identify issues and improve port process efficiency. collaborating to gain control and enhance quality in port operations, contributing enormously to the environment
Augmented Reality (AR) and Virtual Reality (VR)	used to improve the training and safety of port workers. Workers can be trained through simulations of hazardous situations or work procedures to reduce the risk of accidents.
Renewable energy	use of renewable energy sources such as solar, wind, and biomass to reduce their dependence on fossil fuels and decrease their carbon footprint. These renewable energy sources can also reduce the port's energy costs in the long run. Air quality is an important factor to be managed in port operations, as large scale of inappropriate gases contribute to an unsustainable environment (Acciaro et al., 2014; Puig et al., 2014; Peris-Mora et al., 2005)
Drones	used to monitor and control port operations and security. Drones can perform infrastructure inspections, detect problems in real-time, and provide valuable information for decision-making.

Source: *adapted by authors*

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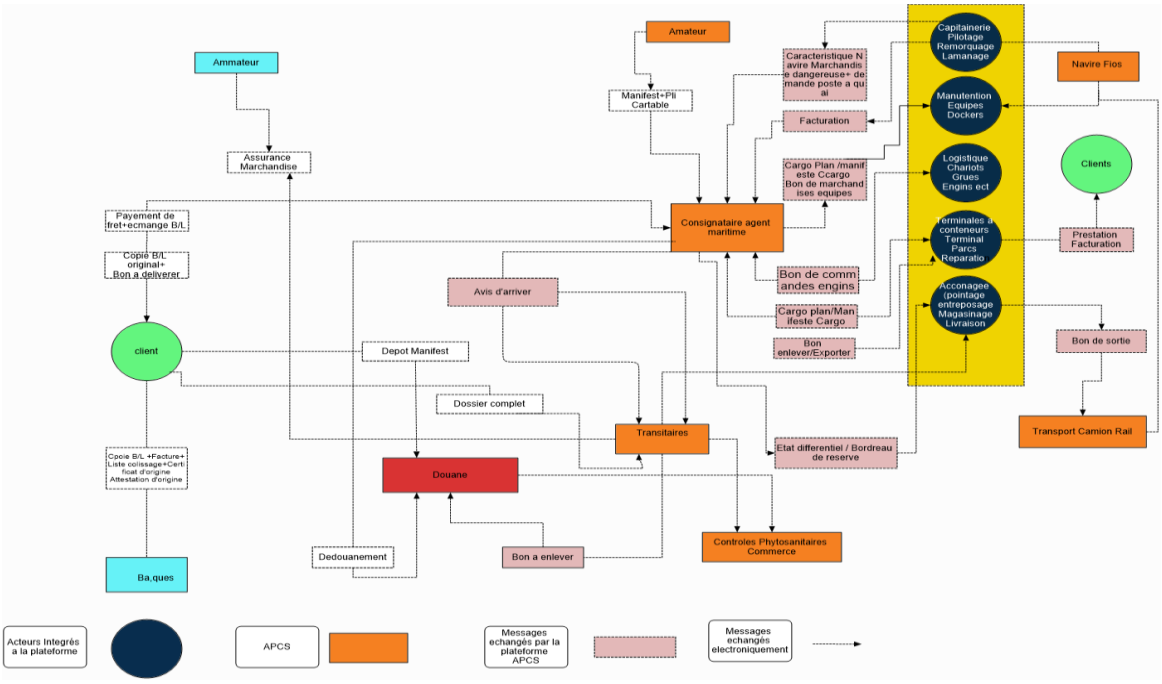
Appendice.2. working process of APCS, 2023.



Source : *APCS public relation office, Algiers, 02 May 2023*

Appendice.3. traditional logistics process of customs clearance of goods

(*) SIGAD : système d'information de gestion automatisée des *douanes*

(**) ENP : entreprise nationale portuaire.

(***) BAE : Bon a enlever.

Source: غربي نجوى، غربي سامية، بوعشة مبارك، مرجع سابق، ص: 1