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ACICSys: An IoT-based commodities intelligent control system to improve the management of Import-export operations in Algerian ports

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***Abstract*---**This work comes within the context of the contemporizing widespread use of digitization in Algeria through the proposal of a smart control system for commodities inside the Algerian ports (ACICSys), based on the Internet of Things, the use of sensors, the cloud computing and information technology which allows an improvement of the current classical check system of the goods. ACICSys assists the decision-makers in upgrading the supply chain process, thus contributing to the transformation of national ports into smart ports that gain competitive strength and enhance the position of the customs sector globally. We also aim, through this system, to contribute to facilitating the quality control and transit of products by minimizing the use of human intervention, especially for agricultural commodities. In addition, ACICSys aims to encourage the digital economy and the penetration of global markets by complying with international standards of products intended for export while minimizing the risk of seeing them returned or damaged.

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***Keywords*---**digital Economy, Internet of things, Algerian customs sector, import-export procedures, customs commodities smart control system.

Introduction

The customs sector is a strategic sector in most countries, because of its role in achieving the goals of economic development by expanding international exchange through the modernization of port management. Countries have focused on this process moving to the application of information and communication technology with digitization techniques for the gradual shift from classic ports to smart ports. In this context, Internet of Things (IoT) is a tool to create added value through its various applications, which are mainly based on connecting different communication devices to the Internet and programming them to automatically carry out without human intervention most of the tasks and functions related to ship self-management, and the necessary smart logistics applications.

In last decade, Algeria has embraced a policy of digitization of its economy in the different sectors. This has brought deep changes to its socio-economic field, expanding its international cooperation. It also enabled their partners to play a greater role in updating and benefiting from them. The customs sector is one of the important sectors in Algeria. The reform of the later witch is still in the early stages of digital transformation, will be beneficial to our country international trade and the national economy as a whole.

The ports represent the core of the customs sector. In this context, Algerian ports are classified globally within the traditional first generation of ports, because their functioning is based essentially on the exploiting of small and therefore uneconomical vessels, and adopt in their management of the rules, classic requirements away from modern developments, particularly in the conduct of customs control procedures such as smart handling techniques containers.

The waiting time in Algerian ports is estimated at 2.95 days, but the usual ship berthing time worldwide is estimated at 0.79 days, as for the international average of the stay of goods on the docks, it is estimated at 1.39 days, but in the Algerian ports it is estimated at 3.99 days to complete the control procedures and customs clearance, (Sadaoui, Kharouf, & Djaber, 2023) this feature caused delays in the handling of goods and the resulting increase in rental costs in warehouses with an increase in the possibility of goods being damaged, in addition to a shortage of the quality of control and the possibility of increasing reluctance of economic operators to deal using Algerian ports. All these factors contribute to the decrease in the volume of Algeria international exchange.

In this context, we propose through our modest work to lay the foundations for a commodities intelligent control system in Algerian ports that we've call - ACICSys - through the basic reliance on technologies available via IoT in order to purpose of managing customs export and import procedures in Algerian ports and passing of products at border inspection points in order to purpose of conducting customs

operations related to the transit of products at border checkpoints, in order to simplify and further clarify how our system works.

We have dealt in our system only with the export process in detail, due to its similarity and proximity in its procedures to the import process. This processing field allows the customs administration to automatically manage the spatial and analytical checks of goods -in particular agricultural products-, which must be cleared, with a maximum reduction of human intervention.

Several successful experiences in the field of port digitization have been carried out, the most prominent of which is the experience of smart ports in China, which is an example to be followed by many countries for what it has achieved for the wearer of access to wealth efficiently and easily. After its adoption in the processing of customs operations on the clearance system to monitor goods along the supply chain through the use of the Internet of things to complete the procedures for the comprehensive examination of goods before their release, especially the process of radiological examination of containers, as well as the electronic signature.

As comparative elements with the Chinese system, we have focused in ACICSys on the spatial aspect by making adaptations in line with the environment of the Algerian customs sector. Our system has been developed in terms of providing a specific platform for document control (the pre-cheking operation) and smart analytical customs control that allows for the detection of the quality of goods, especially agricultural ones, by the use of three detection techniques of acoustic detection, chemical detection, and multispectral image analysis.
We have organized our paper into seven sections. After introduction, we will describe the current control system used at the Algerian ports. In the next section, we present the main features and the operating key steps of ACICSys. The fourth section includes the strength points of commodities intelligent control system in Algerian ports, while the fifth section presents the significant related work through a case study of the detection and control smart system used in China before concluding the paper.

Material and Methods

The Current commodity control system at Algerian Ports

In 2020, Algeria owns 13 small and medium-sized commercial ports. The global trade volume hits then 130 million tons, representing 95% of international trade. These figures show that the ports are considered to have a vital and essential role in the Algerian economy. (Rammini & Mouhammed alcharif, 2020, p. 165)

The import-export operations issues in Algerian ports

In the last decades, the government development policy focused on investing in oil-ports as dedicated ports serving a single economic sector because rent-seeking dominates the Algerian economy (Algeria Invest, 2018). Thus, commercial ports faced several constraints relative primarily to customs control which will be listed hereunder.

Classification of Algerian commercial ports as traditional first-generation ports: first generation Algerian ports or unloading cargo points provide only transportation of commodities using small vessels. Non-economic vessels make up 60% of small vessels with a cargo capacity of 2000 to 10000 tons. These ports show their inability to keep pace with modern technologies in shipping industry like the use of containers which necessitates particular vessels and materials. Therefore, this specification deprives Algerian exporters of advantages provided by modern foreign ports generation. (Mnaouer, 2022, p. 7)

Lack of modern logistics equipment at Algerian ports: out of 13 ports, only Algiers port disposes of a self-propelled container loader of 300 tons, which is mainly used for unloading grain cargoes. If we consider that Algeria is ranked 4th in the world as the most importing country of grain by 7.7 million tons per year in 2021, it will be forced, during the process of unloading ships coming from abroad with a period exceeding international norms by 16 days, to rely only on Algiers port that contains a grain reception centre with a capacity of 30,000 tons.

Inordinate Vessel's turnaround time (VTT) at Algerian ports: vessel's turnaround time at Algerian ports is 2.95 days; however, the usual vessel turnaround time is 0.79 days globally. The international average for goods left at dock is 1.39 days, while in Algerian ports is estimated to be 3.99 days to complete control procedures and customs clearance. Hence, commodity trading process is delayed causing an increase in rental costs in warehouses, a vulnerability of goods to damage, a lack of quality control and a risk of losing economic agents willing to deal with Algerian ports, thus contributing to a decrease in the volume of international trade. (Jedaini, 2022, p. 37)
Increasing reliance on labor: this phenomenon is due to the lack of mechanization (logistic equipment) that requires ongoing training for qualified employees. (PERFORMANCE INDICATORS, 2019)

The control procedures currently applied to commodities within Algerian ports

We can consider the control procedures applied to commodities within Algerian ports as Traditional. In this context, we will describe in what follows, the different aspects associated with these procedures.

Commodity submission to the customs administration

According to the applicable international norms, vessels are not allowed to dock except in ports containing a customs office. This procedure consists in the obligation of bringing commodity for customs control. As soon as the vessel boards in the national customs maritime zone that extends along 24 nautical miles, it is necessary to register the transported commodity in the load permit, which is an inventory signed by the shipmaster and placed at the disposal of customs agents (official journal of People's Democratic Republic of Algeria, 2022)

Procedure of Presentation of commodity to Customs

The carrier presents the commodity to customs with a declaration within the next 24 hours of the vessel arrival at the port. The declaration is a commercial or official document stating the necessary details which allow customs to control commodity by manual control of imported and exported containers, hence reconciliation of data between the presented loads and the actual loads is operated. This procedure extends the waiting period for customs clearance to complete the procedures of commodity control. (UNCTAD, 2020, p. 88)

Commodity Analysis

The only kind of commodity analysis used in Algerian ports is the chemical analysis. After completing customs clearance procedures and the conformity of the delivered goods with the established conditions, the goods are allowed to be discharged. If a doubt is raised regarding goods, it is necessary to be subjected to chemical testing, by taking samples and sending them to the analyses laboratories in order to verify their conformity to the stipulated requirements. In fact, this process requires additional time, which increases the dwell time of containers at port and vulnerability of goods to damage. (Belghazzi, 2022, p. 10) The classic control procedures currently applied on commodity at Algerian ports are showed in figure 1.

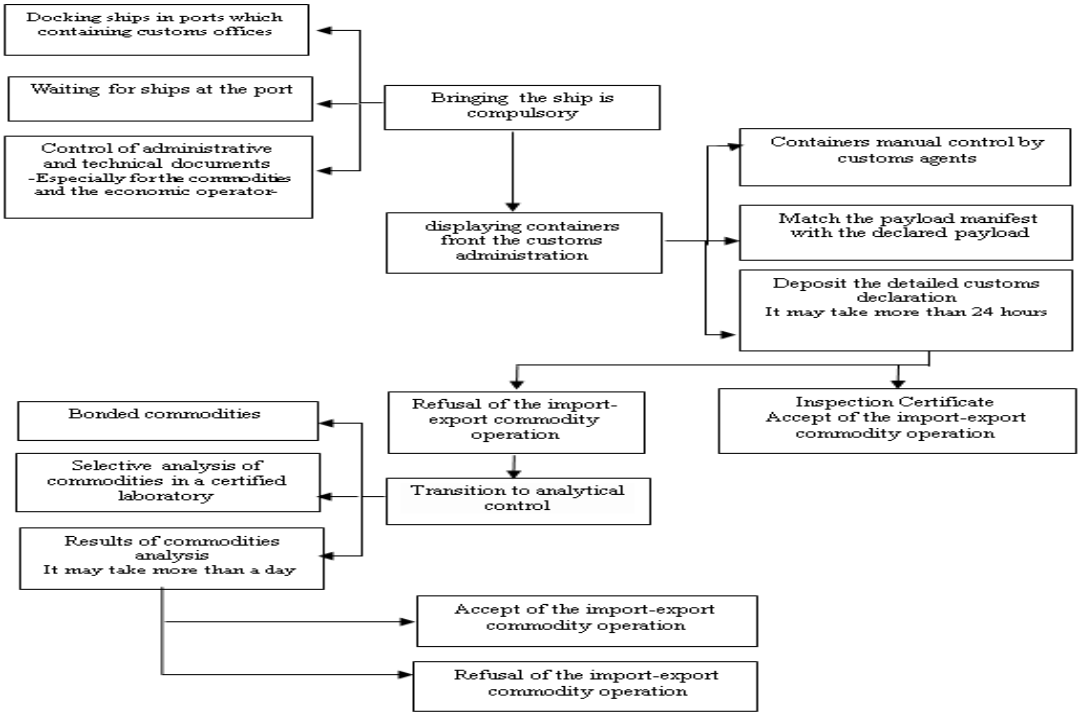

Figure 1: The classic import-export control procedures currently applied at Algerian ports

The classical procedures in managing Algerian ports have not posed any problems since vessels were smaller in term of size, or payload or the process of loading and unloading goods was simpler. However, in time, these facilities are no longer keeping up with the advanced technological requirements imposed by most ports that use specialized large sized vessels.

The difficulty of completing customs control procedures grows more difficult due to the irregular dredging of Algerian ports caused by the lack of maintenance. Hence, it will be impossible for great vessels to dock forcing them to lighten their cargo in other ports then return back to Algerian ports. This procedure results in additional logistics services at non-competitive prices affecting negatively Algerian ports efficiency due to the additional time and effort for loading and unloading, waiting for access to the port, carrying out inspections and the costs of staying in warehouses.

The Algerian Commodities Intelligent Control System _ACICSys_: Our solution for enhancing the import-export procedures in Algerian ports.

In this section, we will describe the most important characteristics and steps of our proposed system to enhance the processing of import-export procedures in Algerian ports.

Overview of ACICSys

In order to provide the basic effectiveness of ACICSys, we focused in the commodities side on agricultural products due to their significant volume in trade exchanges between Algeria and other countries. Another reason for the choice of agricultural products is linked to the recurrent rejection of Algerian agricultural products dedicated to export through Algerian ports. In this context, the amount of Algerian agricultural products exported during the first quarter of 2022 amounts to 20 million dollars. This is a figure below the forecasts for 2022.

Algeria's main obstacle to the export of peasant crops remains the quality standard, which is essentially linked to the lack of control over the chemical processing of Algerian peasant products, (overuse of 5 types of fertilizers and pesticides that are forbidden abroad). These situation affects the percentage of agricultural products acceptance in the European, American and even Arab markets, which are subject to strict standards in the import of vegetables and fruits. (Arabic Post, 2022). The figure 2 represents Main interfaces of ACICSys system.

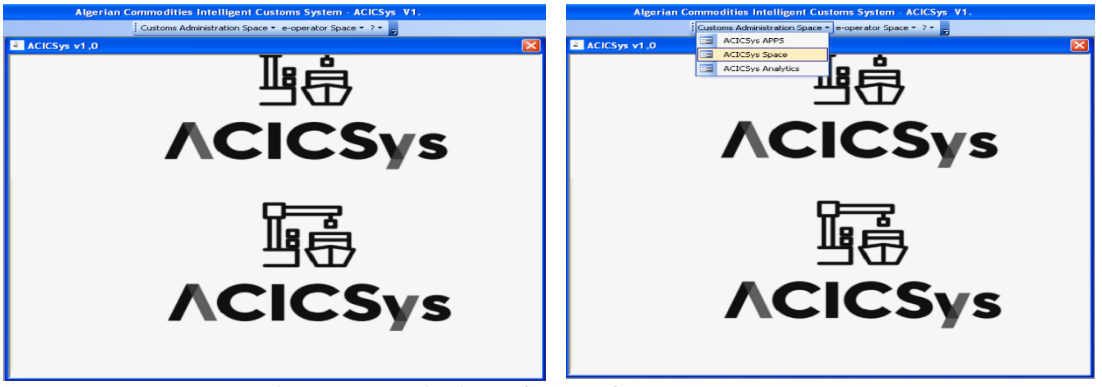

Figure 2: Main interfaces of ACICSys system

ACICSys, which is an abbreviation for -Algerian Commodities Intelligent Control System- in Algerian ports, operates according to smart supervision within the features of the Fourth Industrial Revolution. It relies on a technical protocol to manage control operations at customs inspection centers through the three ACICSys Platforms and a database that include the stipulated quality laws, the used standards, the administrative documents and goods specifications, a Customs Data Analysis (CDA) platform for the examination of goods data. In the next, we'll describe the three ACICSys platforms:

i. ACICSys-Apps: This platform includes: a special section for customs administration agents, and a special section for economic operators. The latter before using the platform, are required to dispose a special account to log in.
ii. ACICSys-Space: This platform is reserved and accessed only by customs administration agents.
iii. ACICSys-Analytic: This platform manages the data related to the three detection techniques of: acoustic detection, chemical detection, and Multispectral image analysis.

The figure 3 represents the operating mode key steps of ACICSys. In the next, we'll describe these key steps.

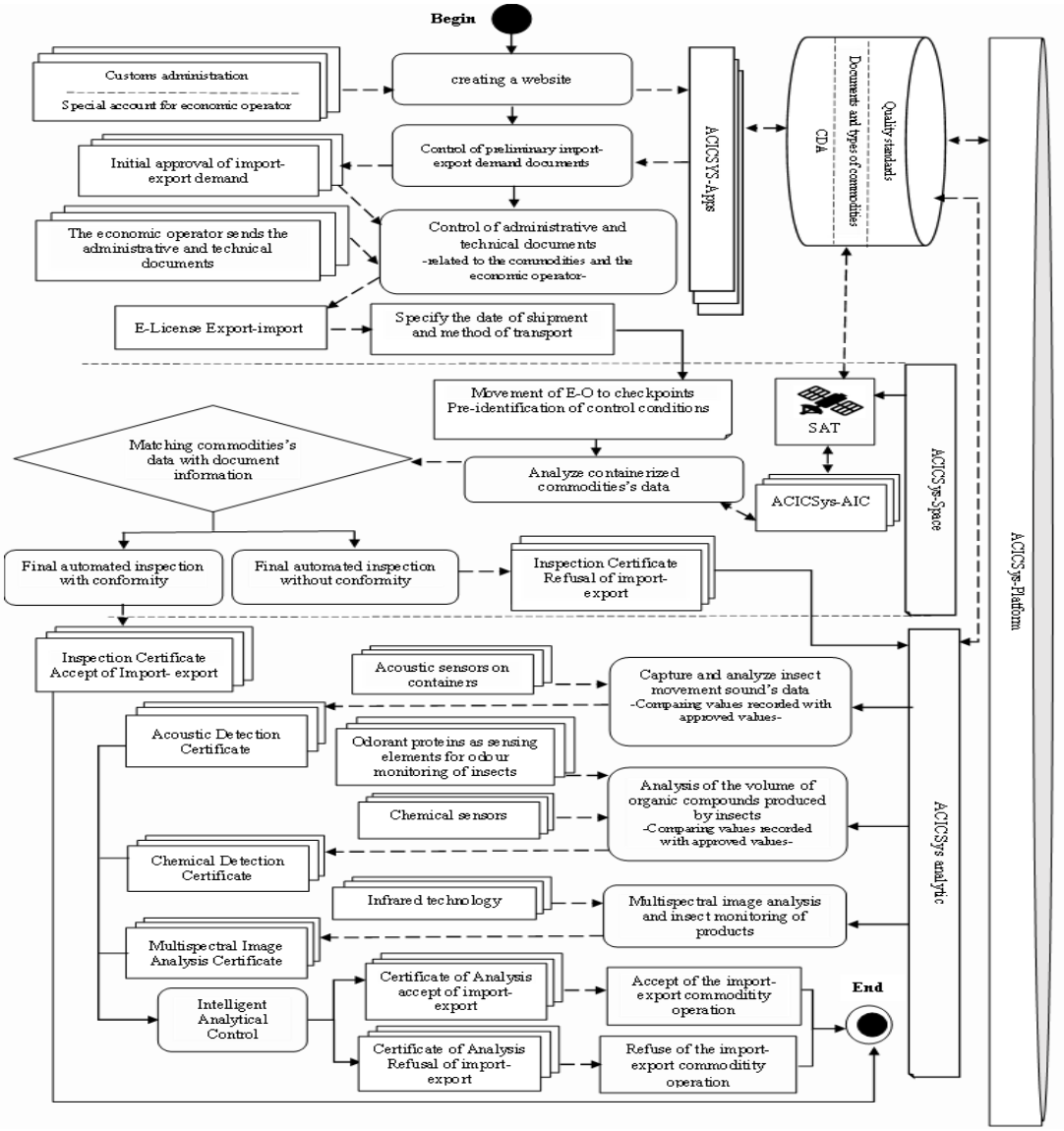

Figure 3: Operating mode key steps of ACICSys

Key steps of ACICSys

ACICSys to work wisely employs the activities related to the following steps:

Establishing a special platform to remotely control commodities documents: The ACICSys-Apps

Aim and objective: This particular platform enables the site users to send and receive documents related to the request of control, as the latter is provided with all the information and quality standards necessary for the commodities. This faculty facilitates the step of automatic check of the content and format of import and export files or documents accompanying the commodities. As the site

provides a special account for each economic operators, including exporters and importers, it enables him to send and receive through this account all information and documents related to any import-export process.

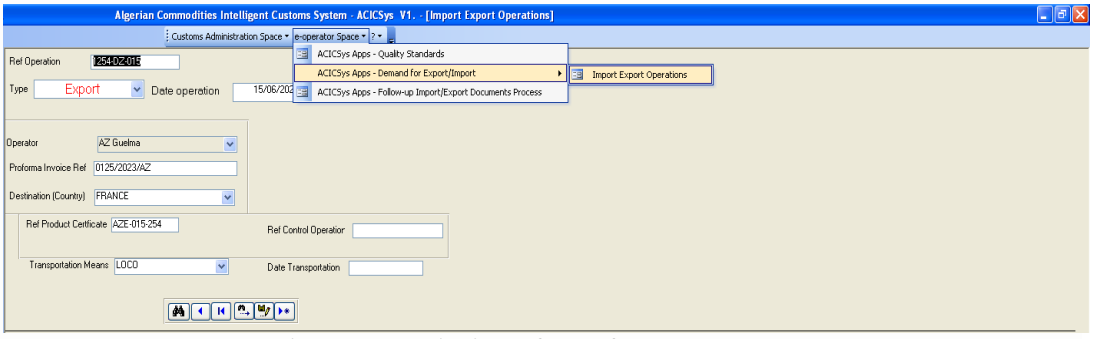

Figure 4: Main interface of ACICSys Apps

Description of the agricultural product exporting process with ACICSys-Apps

- The exporter must first scan the documents related to export operation.
- The exporter must send through his account the export request attached to the scanned documents.
- The customs agent after study of documents can validate or reject the request.
- If validated, the customs agent provides the initial approval using a digital method in the evaluation process and the reasoned answer, which is based on clarifying and explaining the approved conditions. This makes it easier for the exporter to overcome obstacles during the next stages while maintaining the traditional query process that requires the move to customs checkpoints for prior identification of control conditions.
- In case of initial approval, the exporter will be informed by ACICSys-apps.
- This approval enables him to initiate the process of preparing the administrative and technical documents of the goods and sending them through his platform account in order to obtain an export license.
- The export license allows him to complete the control task of documents related to the process with specifying the date of shipment and the method of transportation where among the approved methods among LOCO, FOB, CIF, and CFR. This constitutes as the pre-checking operation.
- The connection of ACICSys-apps site to the National Customs Administration Database allows to cover all import and export operations in accordance with Algerian regulations.

Establishing Intelligent spatial customs control system for commodities inside Algerian ports: the ACICSys-Space.

ACICSys-Space manages the process of matching the commodities data associated with the documents submitted by the economic operator.

The operating of ACICSys-space

This process is carried out according to the following steps:

- After completing the pre-checking related to the documents and obtaining the automated export license, the commodities are awaited on the date agreed upon between the economic operators and the customs administration through the ACICSys-Apps platform. The objective is to complete their export spatial control and orientation.
- Once the containers carrying the goods arrive, the identity of the outgoing and incoming containers is automatically identified by means of an automated identification card – the AIC- which is integrated into all of the containers.
- Whereupon, the AIC automatically sends all these data to the customs data analysis platform -CDA- via satellite. These port characteristics provide the satellite with the ability to send and capture data at long distances, especially since the place of stopping ships in the port may reach 500 meters away.
- The CDA platform of the Customs Administration database allows the analysis of the data of commodities that were monitored in containers before they were shipped or unloaded by IoT services and compared automatically with the administrative documents of the commodities. This is due to its link to ACICSys-Apps to complete the automated inspection process and submit the acceptance document for import-export in the event that the goods data matches the data of its documents on ACICSys-Apps.
- In case of non-conformity, the non-acceptance document for import and export shall be submitted as the case may be and moved to the analytical control of the goods for the final determination of the export-import or seizure of the goods.

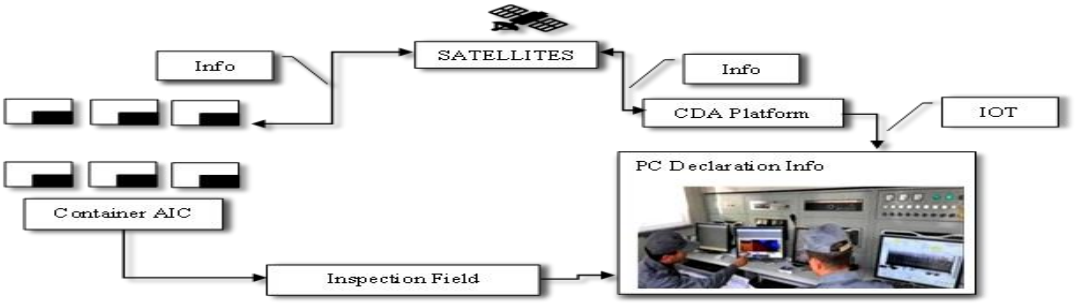

Figure 5: the operating mode key steps of ACICSys-space

ACICSys-Space provides many advantages for the economic operators and the customs sector, the most important of which are as follows:

- Providing security solutions by not relying on error-prone human intervention.
- Supporting this process for flexibility and adaptability to customs management requirements and type of goods.
- Providing security solutions by not relying on error-prone human intervention.
- Providing a total integration quality: the faculty of integration characterizes the system as it can operate completely in an independent way of the rest of other systems.
- Providing a possibility of recording, transporting, analyzing and processing documents and data of goods, as well as the economic operator through the

database of the Customs Administration and the Internet of Things. And providing a possibility of remote control of the automated inspection process via smartphone or computer.
- Using fast scanning technology with high processing of goods data in real time through the achievement of time benefit.

ACICSys-Space has a set of objectives for national economic development. we quote in the following the most significant:
- ACICSys-Space Provides the ability to control customs borders and ports with state-of-the-art technology and automated devices.
- ACICSys-Space contributes to raising economic growth by promoting exports outside the hydrocarbon sector, by improving the quality of national products in accordance with international standards.
- ACICSys-Space allows Setting the dates of export and import operations with dealers, which contributes to reducing the pressure on the ports and increasing the volume of Algerian exchanges with abroad.
- ACICSys-Space allows to achieve the highest levels of national food security and stability in addition to protecting and securing the community from fraudulent business practices.
- ACICSys-Space allows a better risk management through effective control at customs ports.
- ACICSys-Space represents an efficient anti-bureaucracy system that allows to contribute of raising national competitiveness globally by improving the performance of customs and logistics indicators.

Establishing Algerian customs intelligent control system for commodity analysis at ports: the ACICSys-Analytics
The operating of ACICSys-Analytics

The ACICSys-Analytic system or ACICSys-Analytics examines the quality of exported or imported commodity especially agricultural commodities such as vegetables, fruits, and dates.
It tests also goods conformity with international technical standards related to sanitary and phytosanitary measures, particularly making sure it contains no harmful bugs such as weevils, larvae, fruit flies.

The Commodity automatic test includes three stages:

i. Acoustic detection
ii. Chemical detection
iii. Multispectral Imagery Analysis

This process is carried out by means of immediate analysis. The analysis results are drawn automatically and an EX-A customs document/ IM-A customs document is presented on-site based on the examination analysis data that is automatically sent to the Customs Administration Database (CADB) in order to ensure their conformity with the standards and legal conditions of import/ export operations in Algeria. This reduces the rejection of exported commodities by importing countries and the defrayal of its costs. The ACICSys-Analytic system opts for comprehensiveness instead of selectivity which is used by the traditional system to identify samples in the analysis process by scanning all the goods

stocked in containers before shipping or unloading. This lends more credibility to this process and contributes to reducing effort and time. Figure 6 shows this process.

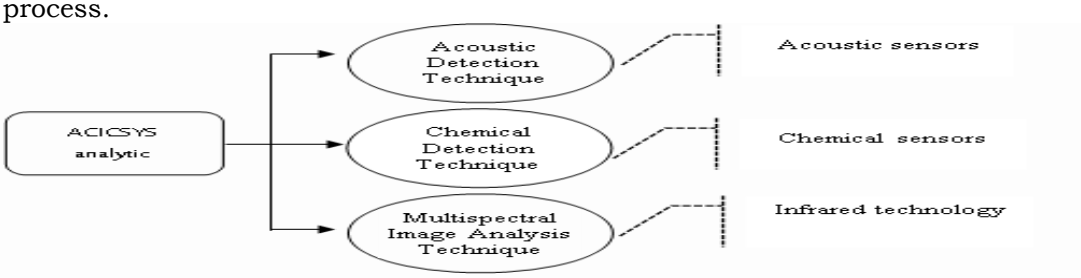

Figure 6: the operating mode key steps of ACICSys-Analytics

The ACICSys-Analytics Acoustic detection

This process indicates the existence of harmful bugs inside containers (such as weevils and larvae...) based on the agricultural product, using the technique of detecting the noise resulting from their activity or their sound while eating these products. The system is operating on acoustic detection relying on auditory sensors placed on the containers to eavesdrop on any remote activity owing to the high sensitivity of these devices in early detection of the minimum movement of bugs and their ability to distinguish sounds to avoid false alarms.

The detection is carried out by placing a sensor in the container whose role is to capture the initial recording of the pest activity in a strict temporal scope then converting it into a graphic frequency that can be analysed and processed automatically. The collected data will be sent later to the customs administration database to compare the recorded values with the approved values. An audio detection document will be submitted supporting the information related to the abundance of pest in the cargo container and then issuing an approval or disapproval within the above-mentioned document. In case of approval, the customer can complete the import-export procedures. Figure 7 shows this process.

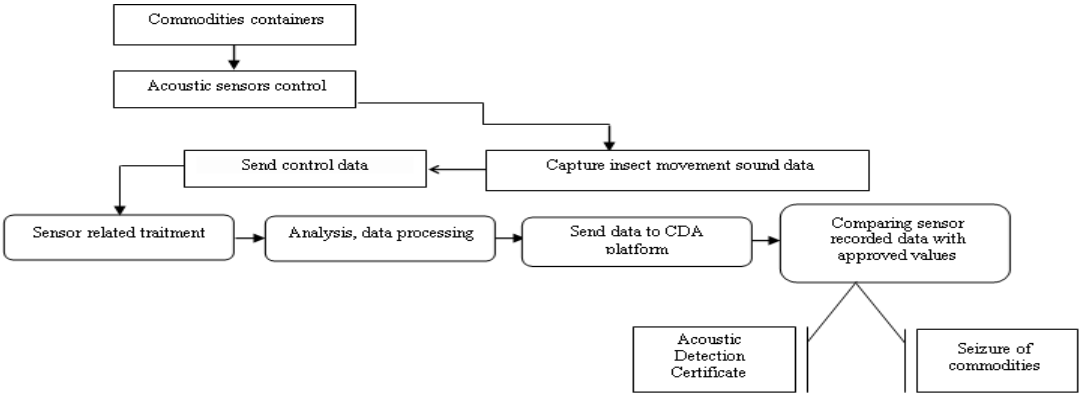

Figure 7: the operating mode key steps of Acoustic detection technique

When eating, bugs show their peak at a frequency of 1651 Hz and a sound level of -19.6 dB. When moving, the frequency is estimated at 1652-2168 Hz and sound level of 9.9 dB.

The ACICSys-Analytics Chemical detection

This chemical detection system is based on measuring the density of volatile organic compounds released by bugs in containers or those created by products starting to perish, using specialized chemical sensing systems. The technology relies on the use of sensors that enable the detection of organic compounds before the beginning of infection. This comes after using the proteins of bugs' smell sense to attract them and then detect the organic pheromone compounds they issued.

Pheromomes are chemicals used by insects to attract other insects. They are produced by a large variety of glands located in different parts of its body. The chemical detection process concentrates on the data received by the sensor. The data is related to organic compounds in goods, it is analysed automatically and sent to the customs administration database in order to compare the recorded values with the approved values, a chemical detection document will be submitted supporting the information related to the abundance of pest in the cargo container and then issuing an approval or disapproval within the above-mentioned document.
In case of approval, the customer can complete the import-export procedures. Figure 8 shows this process.

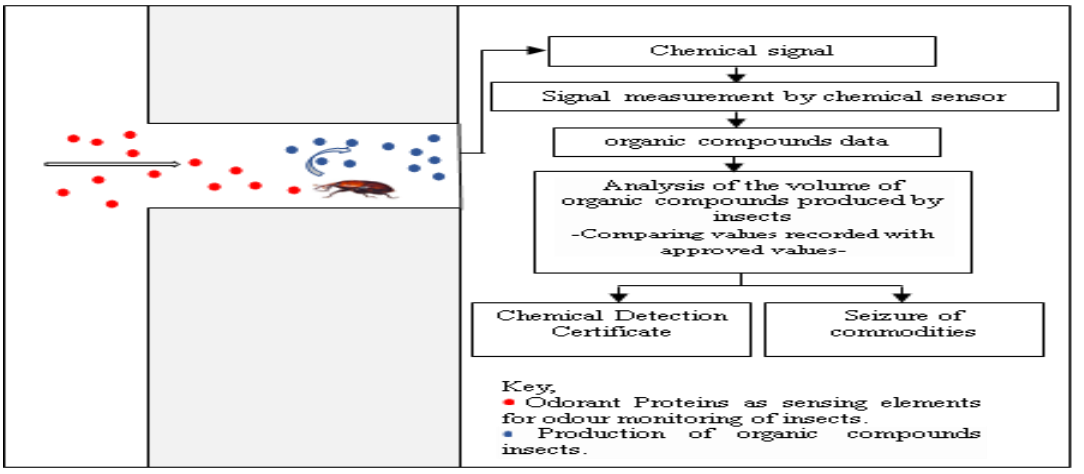

Figure 8: the operating mode key steps of Chemical detection technique

The ACICSys-Analytics Multispectral Imagery Analysis

The multispectral image analysis process utilises infrared technology to capture multispectral images of the products in the containers which helps in the pest identification. The ground of the multispectral image analysis process is to provide the device with infrared technology and to perform multispectral analyses to track insects in agricultural products. This activity is being done by using

thermographic cameras with drones to find changes in the range of infrared radiation in containers arranged on board vessels. The changes vary depending on the temperature and properties of the products subjected to the sensor.

When the pest is subjected to the sensor, the device notes a high level of temperature at that point, rising from the temperature of the normal environment to the temperature of the pest. The temperature declines once the pest is out of this field. Thus, a signal is automatically sent to the dedicated computer at the customs administration in order to detect and track insects in agricultural products. The sensor converts change in infrared radiation into a change in voltage to provide a value that can be compared with the values approved in the customs administration database. A multispectral imagery analysis document will be submitted supporting the information related to the abundance of pest in the cargo container and then issuing an approval or disapproval within the above-mentioned document. In case of approval, the customer can complete the import-export procedures.

The system is technically characterised by:

- Providing high-capacity sensors to track the lowest quantities of bugs in commodities, especially agricultural products. Providing exact and sensitive data.
- Using optical fibres that are highly sensitive to activity (noise….).
- The ability to control this process remotely via a smartphone or computer.
- The system aims at promoting economic development via the following objectives:
- Encourage exporting agricultural crops and particularly dates and wheat, which represent an important economic resource for the country. Improve the Quality of the exported Algerian products keeping pace with international quality standards.
- Control trees export and import process to detect the affected ones and the scale of the pest spread, and reduce the duration of customs procedures related to sampling control of products by providing immediate on-site control.

Results

We will begin this section by presenting the experience results of the ACICSys used detection techniques of infested Algeria's agricultural products dedicated to exports / import. The main contributions of ACICSYs compared to the current control system will be presented later.

The results of the experience of detection techniques on Algeria's agricultural products dedicated to exports / import

Table 1
List of Normative Infestation Densities

Infestation class indicated by probe	Corresponding Normative Infestation Density
zero infestation	< 1 adult insect or hidden form / 10 kg
Possible Infestation	≈ 1 adult insect or hidden form / 10 kg
Low/medium infestation	≈ 1 adult insect or hidden form / 7,5 kg
Medium infestation	≈ 1 adult insect or hidden form / 4 kg
Medium/Heavy Infestation	≈ 1 adult insect or hidden form par kg
heavy infestation	> 1 adult insect or hidden form par kg

Source : Marie-Pierre LEBLANC. Bernard TOMASINI (2009). Study of the potential for direct detection of hidden forms of insects in grain stocks by acoustic equipment. France. P 15.
https://www.aemic.com/blog/article/etude-du-potentiel-de-detection-directe-de-formes-cachees-d-insectes-dans-les-stocks-de-grains-par-des-equipements-acoustiques-i.html

Olfactometer attractiveness of the different larval stages by the smells of fresh dates intended for Export

Table 2
Standard table of larval stages

Larval stage	L2	L3	L4	L5 Male	L5 Female	Chrysalis Male	Chrysalis Female	Adult Male	Adult Female	Full cycle
Duration of Stages (days)	6,04	5,04	4,08	6,4	6,4	6,28	6,28	4,3	4,3	42,42
Average weight (mg)	0,38	2,65	7,34	13,86	19,6	8,01	11,62	5,5	8,55	
Average size (mm)	3,68	6,68	8,92	11,3	12,7	6,2	6,8	7,8	9	

Source: Hadjeb Ayoub. (2011-2012). Influence of the nutritional quality of three varieties of dates on the biological potential of the date moth ectomyelois ceratoniae. the thesis with a view to obtaining the degree of magister in agricultural sciences. Mohamed kheider Bisikra University. Algeria. P16.

Table 3
Olfactometer attractiveness of the different larval stages by the smells of fresh dates intended for Export in Algiers Port

	laboratory experimental measurements		**The Deglet-Nour Agricultural Product measurements**				
	Used quantities 0,05 kg / L = 20		**Exporting: 25514 tons/ L = 102056. 10^5**		**%**	**%**	The used Standard Infestation density (7,5 kg / 1 insect)
Larval stages	**A**	**NA**	**A**	**NA**	**A**	**NA**	Kind of Threshold **[Low/Medium]**
L2	18	2	9.185.040.000	1.020.560.000	90%	10%	-
L3	18	2	9.185.040.000	1.020.560.000	90%	10%	-
L4	18	2	9.185.040.000	1.020.560.000	90%	10%	-
L5	16	4	8.164.480.000	2.041.120.000	80%	20%	-

Key, A= attractive NA= not attractive
Source: Hadjeb Ayoub. (2011-2012). Influence of the nutritional quality of three varieties of dates on the biological potential of the date moth ectomyelois ceratoniae. the thesis with a view to obtaining the degree of magister in agricultural sciences. Mohamed kheider Bisikra University. Algeria. P16.

In our study table 3, we relied on the reference method and results provided by the laboratory (Hadjeb, 2011-2012, p. 17) related to the measuring of olfactory attractiveness of the different larval stages with the smell of fresh dates intended for export, our experiments allowed us to reach the most important results by using the ACICSys chemical detection technique. The later enabled us to detect 90% of the larvae present in the amount of the Deglet-Nour agricultural product. According to the standard measurements (1 insect in7.5 kg of Deglet-Nour) subject to agricultural products export license, we can conclude that the intended for export Algeria's Deglet-Nour that we submitted to our experimentation through ACICSys does not conform to the international standards because of their insect content to the tune of 8,164,480,000 in 25,514 tons While international export standards are around 3,399,740.5 insects in 25,514 tons.

Acoustic detection technique

The research of digital acoustic processing, which was conducted in the laboratory on a sample of grain = 40 kg containing 16,000 insects (LEBLANC & TOMASINI , 2009, p. 15), led to the automatic identification of the noise spectrum produced by the insect among the various sources of environmental noise, especially as agricultural products (grains, dates, fruits) is considered a good sound insulator that enables clear recordings.

The acoustic detection technology used in our ACICSys Analytic system enabled us to detect the value of 3.097.560.000.000 insects out of 3.320.000.000.000 insects in 8.300.000 tons (MILLER, 2022) of Algeria's agricultural imports of grains.

After analyzing the obtained results, it became clear to us through the numbers shown in Table No 1 that Algeria's imports from grains do not comply with

internationally approved export standards (1.103.900.000 insects in 8.300.000 tons) as shown in Table 2.

Table 4
Different insect's Acoustic detection by the grains intended for import at Algiers Port

Agricultural Products : Grains					
Insects Stage	laboratory experimental measurements		ACICSys Measurements		The used Standard Infestation density (7,5 kg / 1 insect)
	40 kg / Insect = 16000		Importing: 8.300.000 Tons / Insect = 3320. 10^9		Kind of Threshold [Low/Medium]
	No-detection	Best-detection	No-detection	Best detection	Norm
L5	6,7%	93,3%	222.440.000.000	3.097.560.000.000	**1.103.900.000**

Source : LEBLANC, M.-P., & TOMASINI, B. (2009). Study of the potential for direct detection of hidden forms of insects in grain stocks by acoustic equipment. Retrieved 4 18, 2023, from https://www.aemic.com/blog/article/etude-du-potentiel-de-detection-directe-de-formes-cachees-d-insectes-dans-les-stocks-de-grains-par-des-equipements-acoustiques-i.html

Multispectral Imagery Analysis technique

Several techniques are used in the field of automatic detection of pests by means of images, including the detection technique through the multispectral image analysis technique.

This technique is among the most difficult methods to use due to the necessity of providing accurate information about size, texture, and colour for small insects, during which we have to rely on capturing a large number of images used as inputs for the detection model that must be adapted to a specific quality that enables the activation of captured images include the following data: low amount of noise, clear picture, Sufficient brightness, and Segmentation of images by removing the yellow background using a fixed binary threshold to facilitate identification and classification of insects (Boutra, 2019, p. 8). This experiment is shown in Figure 9.

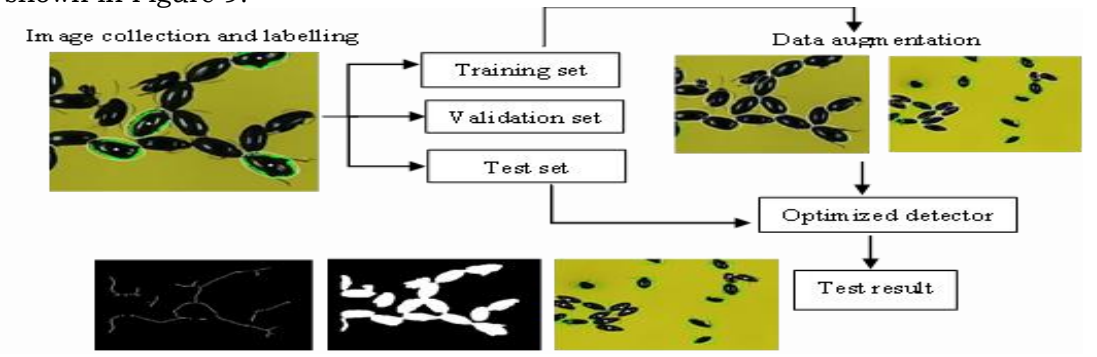

Figure 9: Deep learning Process chart to detect insects in Algerian Ports

Source: Boutra, N. (2019). Automatic Recognition by Imaging of Insect Pests of Rapeseed. Retrieved 5 3, 2023, P 19. From https://dune.univ-angers.fr/fichiers/18009355/2021TMMA14144/fichier/14144F.pdf .

Through the results of analyzing the collected partial images, which exceed 400 images (Boutra, 2019, p. 19), the experiment allowed to: successful detection of all insects, and 6 pests out of 15 cannot be predicted despite their being detected presence.

Hence, we can conclude that if the multispectral image analysis technique is applied to Algeria's exports of agricultural products by containers, we will not be able to detect only an amount that does not exceed 60% of the insects present in them.

The key comparison aspects between ACICSys and the current control system

ACICSys has strengths that cover the deficiencies of the current system, Table 5 illustrates this aspect.

Table 5
Key Comparative aspects between ACICSys and the Current Algerian Control System

	Inspection and control function	
Standard of comparison	**by ACICSys**	**by the current system**
ACICSys Apps		
Time	<10 minutes	>24 hours
Examination method	Automatically	Manually
ACICSys Space		
Time	<10 minutes	>2 hours
Examination method	Scaling back human intervention	Human intervention
Error rate	<1 %	>40 %
ACICSys Analytic		
Time	<10 minutes	>24 hours
Examination method	immediate	In vitro analysis
Error rate	<3 %	<20 %
Analysis Pattern	Inclusivity (exhaustive)	selectivity by samples

We finally show the key steps necessary for the transition from the current system to ACICSys

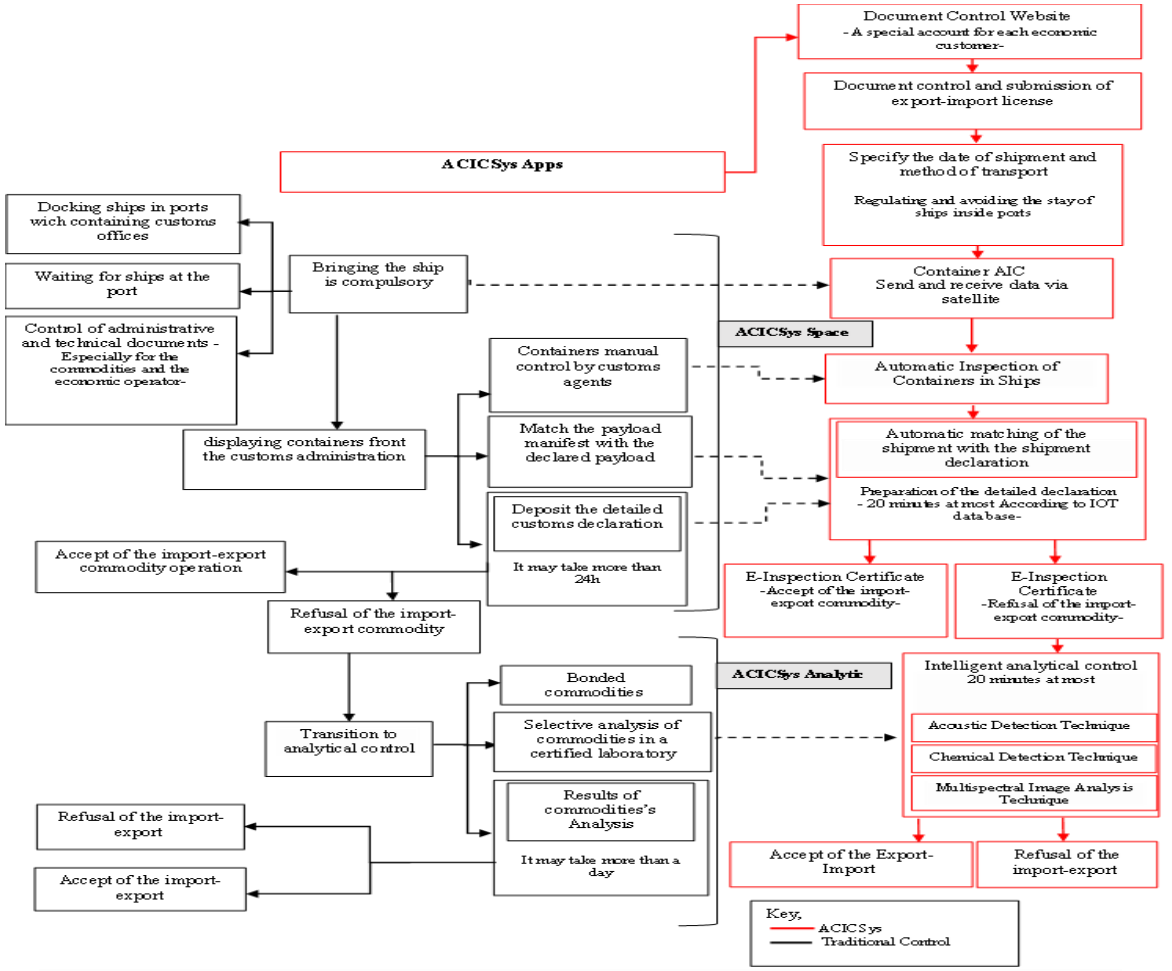

Figure 10: the transition key points from traditional control to ACICSys

The results showing the strengths of ACICSys are illustrated through the following points:

- Decreasing of logistics costs. Reducing the cost burden of the traditional control system.
- Achieving fair and secure foreign trade. Allowing Customs Clearance with high efficiency.
- Allowing a better Exploitation of the agricultural sector and economic diversification.
- Attracting economic operators and raising the export rate.

For the purpose of improving the control function at the Algerian ports and bringing nationally adopted standards closer to modern ones and at the same time avoiding high costs of shipping and unloading and total reliance on document papers, we have proposed a new system based on the application of IOT at all procedural levels associated with oversight and related to the control of commodities inside Algerian ports under the name of ACICSys.

The latter is based on three platforms, each of them performs a specific function in the system. it is about the following platforms: ACICSys-Apps, ACICSys-Space, and ACICSys-Analytic.

Discussion

The key comparison aspects between ACICSys and China Smart Customs Clearance System

We will present the key comparison aspects between ACICSys and China Smart Customs Clearance System

Table 6
Comparative elements

standard of comparison		ACICSys	China Smart Customs Clearance System
Materials		- IoT - Wireless Network and Cable Network. - Connected objects. - the cloud computing. - Acoustic sensors. - Chemical sensors. - Infrared technology. - Satellite. - customs data analysis -CDA Platform- - Container automated card identification -AIC-	- IoT - Wireless Network and Cable Network. - Radiate Inspection. - GPS. - E-Barrier. - E-Seal. - E-Load Meter. - Logistics Information Platform.
Software	ACICSys Apps	- Automatically. - A special account for each economic customer. - Specify the date of shipment and method of transport. - Export/Import E-License.	- Automatically. - Export/Import License.
	ACICSys Space	- identifications of the outgoing and incoming containers are automatically achieved by means through an AIC. - Container Radiate Control. - Satellite Auto-Tracing - Analyze containerized - commodities's data. - Matching commodities's data with document information. - E-Inspection Certificate (Accept/ Refusal of the import-export commodity).	- Container Radiate. Inspection. - Auto-Container ID Recognition. - GPS Auto-Tracing. - Electronic barrier gate when entering and exiting containers at checkpoints. - E-Inspection Certificate.
	ACICSys Analytic	- Immediate. - Acoustic Detection Technique - Chemical Detection Technique. - Multispectral Image Analysis Technique. - Inclusivity.	- In vitro analysis. - Selectivity by samples.

Related Works

In this section, we will address a most important related work through a relevant study of China's smart customs clearance system. The unprecedented spread of the COVID pandemic has reinforced the provisions aimed at avoiding manual checks by customs officers, due to the high risk of infection in addition to that of economic operators. (Varese, Cesarani, & Wojnarowska, 2022, p. 3) This situation

has caused a lack in the conduct of goods inspection operations and the postponement of controls of the associated economic operations.

Therefore, the customs sector had to take advantage of modern inspection equipment and rely on automatic detection of commodities without human intervention. (Zhiqiang, 2020)

This is the approach taken by China, which has used Internet of Things technology to develop an intelligent cargo detection and inspection system in order to complete the customs clearance process. (World Customs Organization, 2021) The following figure illustrates this approach.

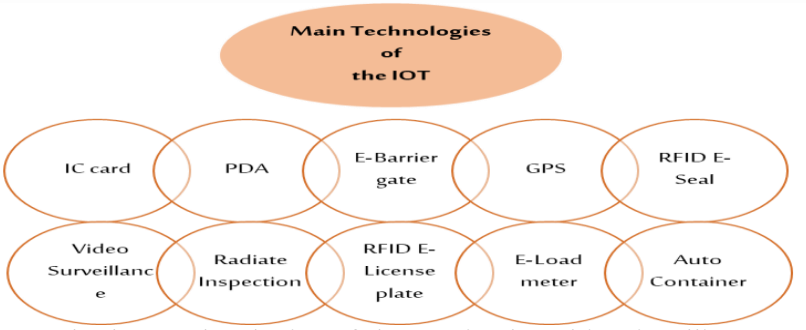

Figure 11: The key technologies of the IoT in the China intelligent customs clearance system.

Source: General Administration of Customs of the P.R.China. Retrieved 10 22, 2022, From http://english.customs.gov.cn/service/guide?c=a0d40abf-0914-4882-a0b2-20c39e0aee12&k=52

IT serving the customs smart system

China Customs has adopted a smart solution to activate customs control, through the use of advanced techniques to renew and update inspection controls of exported and imported commodities. In the following, we will present highlight of the master plan, which includes the elements that form the backbone of the transition from traditional manual detection and inspection system to a smart customs clearance system.

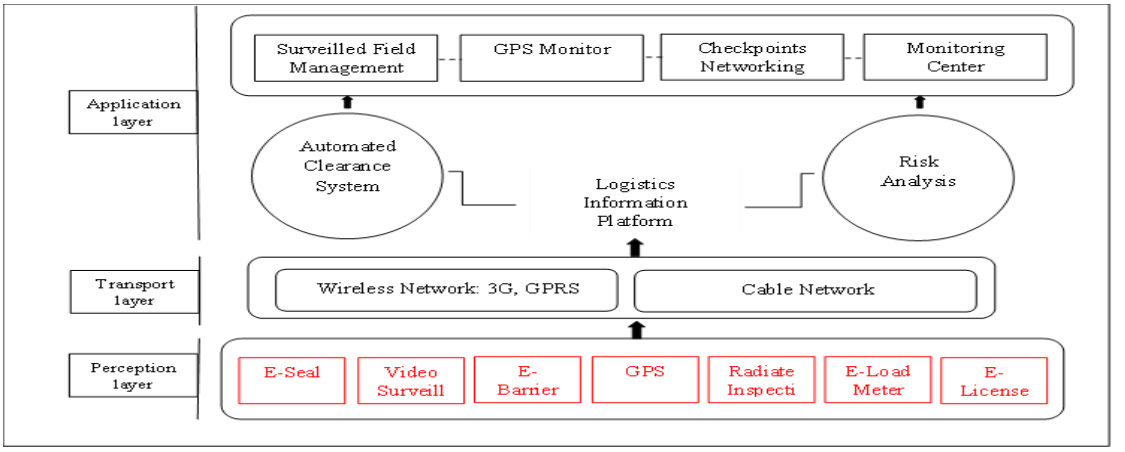

Figure 12: Outline of key elements for the transition from the china traditional control system to a smart customs clearance system

From the figure, we note that the clearance system relies on a set of technologies such as the electronic seal, the electronic reservation portal, and automatic tracking... which are linked via wired and wireless networks to the logistics information platform, in order to facilitate the completion of the automatic clearance system operations at checkpoints, control centers, and field management subject to monitoring, which also helps to prepare a future vision that enables the analysis of risks to avoid or overcome them. (United NationsConference on trade Development, 2020). The Customs IoT application platform enables the system to control the areas of customs administration, the most important of which are: Entry and exit of territory, Entry and Exit of Surveilled Area, Manage Inner Surveilled Area, and Link the IoT platform between customs areas and facilitate the transfer of information and shipments. (General administration of customs people's republicof china, 2022)

Smart Customs Clearance System Working Method

In processing customs operations, the Chinese Customs Administration has relied on the smart clearance system, which is related to smart inspection in order to control commodities along the supply chain through technological equipment such as RFID and GPS sensors that are the basis of the Internet of Things, with radiological examination of containers and automatic identification of their identity to complete the examination procedures, e-seal and release of exported or imported commodities. (World Trade Organization-World Customs Organization, 2022, p. 19). The safe storage of customs operations information of system is carried out as well as the transmission of all business operations data through the Customs Platform of the Internet of Things. Moreover, the later facilitates big data analysis and information transfer to the monitoring center. (KOCAMAN & BİÇİMSEVEN, p. 19)

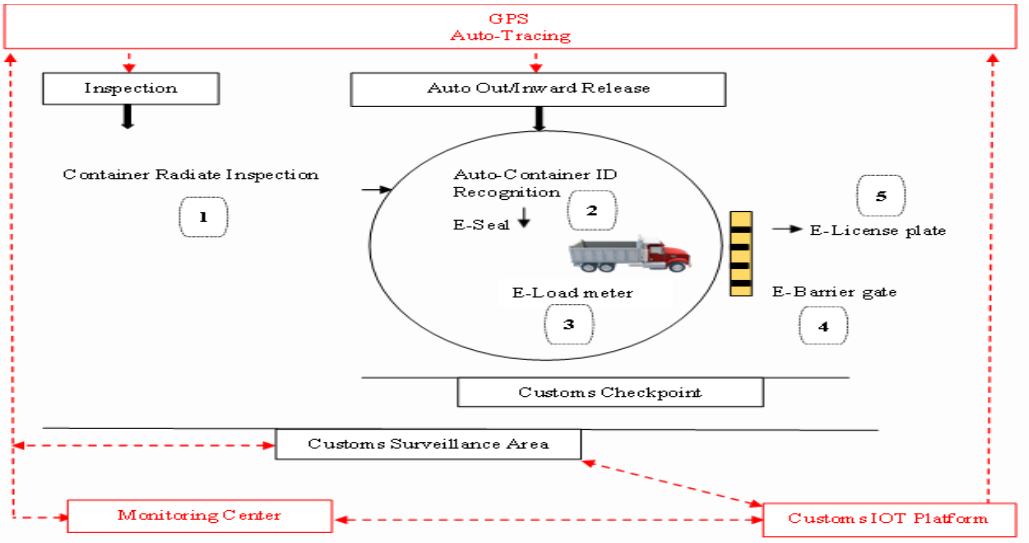

Figure 13: Outline of the control completing operations under China's smart clearance system

The Chinese system makes contributions to the activation of economic development, the most important of which are:

- Improve the efficiency of logistics services performance, providing high efficiency in the customs clearance process and Manual reduction of the workforce.
- Reduce the cost of logistics, and facilitate and secure cross-border trade.

In light of recent developments, the Chinese system objects many challenges, the most important of which are the following:

- A system characterized by a general measurement standard, not a specialized one.
- Providing financial, logistical and scientific requirements related to scientific research and continuous development in the field of information technology.
- The necessity of continuous and adaptive control of the requirements of commercial openness and the obligation to achieve national security. (Ruijian, 2013)

Conclusion

The traditional Algerian ports have seen during the last decade, their storage and loading / unloading capacities increasingly limited with an increase in the processing times of the files of the economic operators and the waiting times of the ships above international standards in addition to a significant number of returned commodities.

In order to remedy this situation, an alignment of these ports with the international standards used by the smart ports has become unavoidable. It is in this context that our work takes place through the proposal of an intelligent system (ACICSys) based on the prowess of the IoT and information technologies in order to provide solutions for the customs sector. These solutions enable to provide various services and opportunities, through the advantages of IT and IoT

like speed of data collection, analysis, control, storage, as well as smart decision-makings about the management of logistics and transportation services by linking them through the unified IoT platform of the Algerian customs sector as a whole.

ACICSys with a basic reliance on technologies available via the IOT and the use of sensors, cloud computing becomes able with a minimum of human intervention to purpose of automatic control of the conduct of customs procedures in Algerian ports and the transit of products at border checkpoints for commodities to be customs.

Our work was inspired by the Chinese clearance system that we have adapted to the particularities of the port management in Algeria relating to import-export operations. These adaptations enabled ACICSys to work on line with the environment of the Algerian customs sector through the smart spatial customs control system ACICSys-Space.

In addition, our system has been developed in terms of providing a specific site for pre-checking document ACICSys-Apps and finally a smart analytical customs control system that allows the commodities quality detection ACICSys analytic, especially agricultural ones, by the use of acoustic detection, chemical detection, and multispectral image analysis techniques.

Finally, we hope that this system will help transform Algeria's national ports into intelligent ports. This aim will lead to a gain in competitive strength and enhance the position of the Algerian customs sector universally, in addition to encourage local goods penetration into global markets by complying with international standards for export destined products with avoiding the risk of have them returned or damaged. We have tested our work with the customs administration at the port of Algiers; an extension to other Algerian ports, as appropriate, will be considered in our next work.

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