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Analysis of the level of market penetration of terminal operating system at port container terminals in Spain

Final Degree Project

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Chapter 1

Introduction

1.1 Summary

Operation of ports and their constant improvement of management is of vital importance for each economy of the country that has maritime connections. Today, with the expansion of multinational companies that transport their merchandise by sea, ports must face greater volumes of merchandise and offer the best conditions for the efficient operation of their port operations. Container terminals that process merchandise, faced with demand from suppliers, are forced to improve their technologies and be able to provide the best efficiency and lowest costs for companies. One of the important tools for the proper functioning of the container terminal is the terminal operating system (TOS) that it uses, as it provides modern management solutions.

The objective of this bachelor thesis is to analyze the level of implementation of terminal operating systems in the ports of Spain and to observe their technological progress.

1.2 Introduction

A terminal operating system (henceforth TOS) is a key part of each supply chain and its objective is to control the movement and storage in container terminals and in the port in general. Choosing a good TOS is critical because it encourages the user to take full advantage of both work and equipment. In addition, it helps to prepare work and facilitates more profitable decision-making. These operating systems also use other technology such as EDI processing, Wireless Local Area Networks and Radio Frequency Identification (RFID) to effectively monitor the movement of goods within, outside and around the terminal. System data is usually transmitted in real-time wireless to the central database. The data collected may provide valuable reports on the condition of machines and other items in the terminal. The purpose of the terminal operating system is to provide an accessible and reliable solution for port terminal facilities that can be separate systems, run as a service or even cloud-based. Therefore, the following work will be focused on the analysis of the existing TOS solutions on the market and their level of implementation in the ports of Spain, as well as the review of the main container operating terminals.

1.3 Thesis objectives

In summary, the objectives set out in this work are:

- Study the main suppliers of TOS, their main characteristics and the presence in Spanish ports;

- Analyse the degree of automation of the ports;
- Study the main port terminal management companies;
- Define the current situation in relation to the technological advance of the ports;
- Study the main TOS providers and available TOS packages on the market, the characteristics of the different TOS packages, their advantages and disadvantages;
- Study the possible correlation between the positioning of Spanish ports and the degree of use and implementation of TOS.

1.4 Connection of the thesis with Sustainable Development Goals (SDGs)

With technological development comes a significant impact on the environment, for the same reason and due to the current world situation, the United Nations has launched an initiative of sustainable development goals.

In relation to the present work, one can talk about the Impact of operating systems and, specifically, about the opportunities and obstacles of digitization when it comes to achieving the objectives proposed by sustainable development and the Green Deal proposed by the European Union. In order to accelerate the movement of goods and provide greater and more efficient data exchange, the future places high requirements on paperless shipments. The objective of realizing this goal requires that as much as possible of the product management should be done digitally. This is precisely what modern TOS is all about: promoting the flow of knowledge and minimizing the use of paper.

It is also important to note that the sub-section of publications on port strategies for climate change does not concentrate on understanding how ports can slow down or mitigate climate change, but rather on how ports can respond to the effects of climate change.(e.g. Ng et al., 2018, Yang et al., 2018).

Environmental sustainability is one of the goals when optimizing the port operations. Remote monitoring technologies could be used with TOS to improve the energy and environmental performance of the equipment. Real-time tracking also provides operators with the information on fuel consumption, running temperature and oil usage. In addition, the idle times of the machinery could be detected as to excessive air emissions and noise on the terminal (Barrons, 2013). Moreover, automation of the equipment contributes to a safer working environment lowering accident rates and thus the insurance costs as well. Furthermore, automated facilities extend equipment life-cycle which could contribute to the ambition of a novel Green Deal published by European Commission (EC): Mobilizing industry for a clean and circular economy. The Green Deal also provides financial support to investments which are considered sustainable. The financial strategy is not yet published in that matter, but it is already known that sustainable investments are considered to be the following:

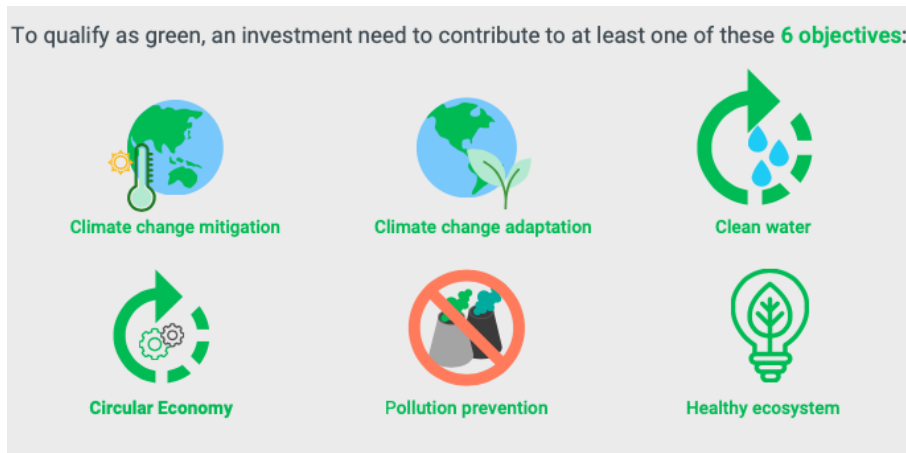


Figure 1.1 Green investment classification. Source: Own elaboration on the information provided by European commission.

Taking into account all the above, the implementation of the TOS and automation of the terminals is not only sustainable, but also could be seen as an initiative to be supported by the novel Green Deal.

However, some recent studies claim that the theoretical implementation is still far from the practice. It is hypothesized that the literature provides an inadequate framework for decision-making on environmental issues in ports (Bjerkan et al., 2019). The justification is that there are a few articles relying on empirical evidence. While, usually, maritime transport is considered to be an environmentally friendly mode of transport, 10-15% of global maritime emissions are accounted for by the maritime industry. Emissions of anthropogenic sulfur (SO_x) and nitrogen oxide (NO_x) and nearly 3% of carbon dioxide (CO₂) (Eskeland and Lindstad, 2016). In response, in 2018, the member states of the International Maritime Organization (IMO) set an absolute goal of reducing GHG emissions by 50% by 2050 compared to 2008, referred to as the "Paris Agreement for shipping" (GreenPort, 2018). It will take a considerable effort to achieve these reduction targets in terms of new technology and other steps to adjust the maritime sector towards zero emissions.

1.5 Connection of the thesis with the subjects studied during the degree

The purpose of the following Final Degree Project is to analyze the level of implementation of terminal operating systems in the ports of Spain, therefore, knowledge of the Spanish and World Economy will be important as it is the sector that influences foreign trade. In addition, it is important to have an overview of the competence and functioning of a country's economy and its macro and microeconomic factors that are acquired in subjects such as Macroeconomics and Microeconomics. There is also higher importance of the knowledge of the subject Strategic Plans in companies as it

is a sector study. In addition, Market Research and Statistics module to provide relevant findings through data analysis and use of R software.

Chapter 2

Literature overview

There have been plenty of studies concentrated on ports efficiency and container terminals themselves, but there are also some of them which specifically addressed the efficiency of Spanish Ports. Pablo Coto-Millán (Coto-Millán, 2000) in his study aimed to analyse the economic efficiency based on the data over 1985-1989. He used an estimation with the frontier cost function obtaining indices of economic efficiency. The results of his study indicated that the most efficient ports are the ones which are *"smaller in size and managed under centralized regime"*. He also concluded that a greater autonomy in management led to greater economic inefficiency. In addition, a lack of technical progress has been detected over the period. About 30 years have passed and we can clearly see that not only many technologies have developed through the years but also the ports and its terminals started adopting them under the important growth of trade and the provided demand for different kinds of goods especially due to the appearance of such companies as Amazon, Aliexpress, Inditex and others. Another more recent study not only on economical but also technical efficiency has shown that *"the companies will not obtain significant efficiency benefits due to relocating to bigger ports or for the fact of being a subsidiary of a shipper instead of an independent firm"* (Gutiérrez, 2015). As for automation, the paper provided by Valencia Port Foundation on automation in port container terminals has stated that: *"in the port domain the greatest proponents of automation are port container terminals"* (Martín-Soberón et al., 2019). Furthermore, the paper argues that *the level of standardization and specialization* is what allows for a higher degree of automation of equipment and processes in this form of facility, in particular: the standardization of the means of transport of containers and of the way in which freight is handled. It also emphasizes that European and Spanish port policies have embraced automation initiatives for a long time, but highlights the importance to consider the unique needs of the port container terminal in the implementation of any commercial automation solution in question. This work gives a good review of the latest port trends and clearly explains the differences of different levels of automation nowadays. As such it gives an example that automated terminal is used to refer to PCTs which in reality have only automated the movements in the yard and dock-yard interchanges, semi-automated term is referred to major automation such as implementation of ASCs and AGS and at the same time for minor automation. As for studies related to the Terminal Operating System itself, it could be said that there are no many scientific articles on this topic specifically, but rather mentions along with other systems available at ports but there is a growing interest on that topic which is confirmed by the frequency that TOS started appearing in scientific articles: "From 2015 to 2017, the number of publications related to TOSs exceeded 50" (Renken K., et al, 2018). Nevertheless, there were two remarkable articles published on the topic of TOS efficiency and its evaluation by Yvo A.Saanan and Csaba A.Boer: *"Plan Validation for Container Terminals"*(2014) and *"Controls: Emulation to Improve the Performance of Container Terminals"*(2008). The paper argues the utility of the emulation tool called CONTROLS (CONtainer TeRminal Optimised Logistics Simulation) introduced by TBA BV. Emulation refers to a software program or physical system's ability to simulate another application or device that is also a software. Emulation is often known as a certain step in a regulated system's testing process. CONTROLS tool was developed in order to reduce the risk and expenses while implementing a TOS solution. The conclusions of the study held were that in the virtual environment provided by CONTROLS, problems caused by TOS can be identified and solved instantly while remaining

connected to reality in a cheap and safe form (Saanen, 2008). It is worth to mention that nowadays, CONTROLS tools is a mature product which efficiency have been proved with the following container terminal operating systems: Autostore, SPARCS N4, TOPS, OPUS, SPACE/Trafik, CATOS, nGen and Zodiac (according to the information published on the website of TBA group in 2020). In addition, according to the study published in 2008, the most popular TOS solutions in the market by then were SPARCS (N4 by Navis), Space/ Trafik from Cosmos and CATOS from TSB and we can clearly observe that despite of the new entries on the market, these ones still remain on the latter and NAVIS is the most complete and advanced solution on the market and undisputed leader as was confirmed in latest findings (Hervás-Peralta, M. et al., 2019)

2.1 ICT systems in a port

Port Community System

The Port Community System (PCS) is the electronic platform that connects systems operated by a variety of organizations that make up a port community. It is an open and neutral system that facilitates the exchange of documentation in a safe and intelligent way between private operators and public entities with the aim of improving the port's competitive position.(Giménez Salazar, 2017)

Automatic door system

The Automatic Gate System (AGS) is a system that uses technologies such as image recognition to automatically identify vehicle license plates, ISO containers, and automated kiosks to facilitate controller interaction with the control system of doors. In this way, access to the port or terminal can be determined very quickly.

Automatic stacking crane

Automatic stacking cranes enable the highest possible capacity and stacking density. In larger terminals, where throughput and stacking density are significant primary performance metrics, ASCs are usually used. They can, however, also be cost-effective solutions for medium-sized terminals in the long term.

Optical Character Recognition (OCR)

The Container Number OCR framework automatically recognizes documents and verifies both set and moving situations with the Container ID number. The system is designed to ensure precise container movement for effective container loading and unloading. The system facilitates efficient gate, yard, and load & unload zone management and operations for modern ports and terminals.

RFID

Radio Frequency Identification is an automatic identification and data collection (AIDC) technology, or, as it is more generally known, RFID. RFID has become an omnipresent, indispensable part of our everyday lives at work as well as at home, from access cards to passports to toll tags. For the identification and monitoring of persons, assets and inventory, RFID provides unique benefits.

ALPR

Automatic container code recognition (ACCR) targets specific codes that are particularly valuable in logistics and operations for shipping containers. To ensure they are on-track and not delayed, shipments can be tracked. When a container enters or leaves a port or storage area, security personnel may also be alerted.

Terminal Operating System

The Terminal Operating System (TOS) is a system dedicated to managing large container terminals. The central system includes modules to plan and control the arrival of ships, cargo handling control, operations and access control, optimized operations and management of auxiliary devices.

Before the analysis of the current situation on the market, let us introduce the concept of terminal operating system by providing several definitions used by some of the relevant sources worldwide. The TOS is also referred to as “the central nervous system” because of its capability to automate a large number of processes. Various definitions can be seen in the research papers and other literature. The following definitions were mentioned in some of the research papers:

- “A TOS provides a set of applications to collect, store, manage, analyze, and disseminate information from different terminal activities in order to provide an integrated view on core terminal processes and ensure an efficient use of resources for handling cargo” (Heilig, 2017);
- “A Terminal Operating System (TOS) is a software system that provides functions to manage and control the movement and storage of various cargo types on and around terminals. Its basic task is to support the logistic processes.” (Fraunhofer Center for Maritime Logistics and Services CML, 2016, p.14);
- “A terminal operating system (TOS) is referred to as a computer system that is designed to plan, track, and manage the movement and storage of all cargo, the use of assets, and the deployment of people in and around the seaport terminal of the port (including the hinterland) on a real-time basis.” (Min, Ahn, Lee, & Park, 2017, p.4);
- “Terminal Operating System (TOS) is the core application used by container terminals for both for planning, monitoring and executing the container's movement from truck to yard, yard to truck, truck to vessel and vessel to truck using heavy lifting equipment”. (Jamal, Sarno, & Ginardi, 2017).

Chapter 3

Current Situation

3.1 Sectoral analysis of the terminal operating companies

Let us approach more in detail the position of container terminals on the market and its role in the logistics and maritime industry. We will further analyze it using Porter's model of the 5 competitive forces which would give us an overview on relations within those forces: maritime transport market from the perspective of competitive forces of suppliers, buyers, potential entrants, substitutes and regulations.

First of all, we must mention the industry competitors which exist on the market: the leading container terminal operators worldwide.

The operating company is the one who decides which TOS to implement and other strategic decisions as to where to place their terminals or take over already existing ones.

According to the Lloyd's list on maritime intelligence the list of top 10 container operators worldwide is the following:

Company	Country	TOS
 The World's Port of Call	Singapore	In-house TOS
	Hong Kong	nGen(Own TOS)
 中遠海運港口有限公司 COSCO SHIPPING Ports Limited The Ports For ALL	Hong Kong	
	UAE	Zodiac(In-house TOS)

	Netherlands	
	China	NA
	Switzerland	Catos and N4 at Spanish Terminals
	Philippines	NA
	Taiwan	NA
	USA	Mainsail and Intermodal Pro (by Tideworks)

Table 3.1. List of top 10 container operators worldwide and TOS in use. Own elaboration. In the following graph could be seen their presence in the main ports worldwide:

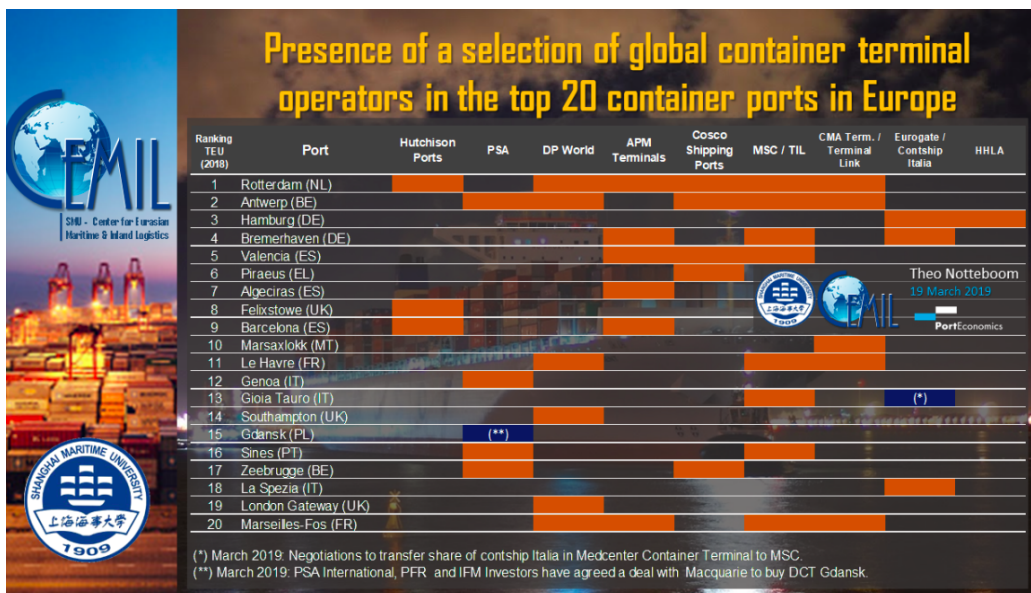


Figure 3.1. Presence of a selection of global container terminal operators in the top 20 container ports in Europe. Source: EMIL.

As for Spain, in Figure 3.2. we can see the following distribution across the country:

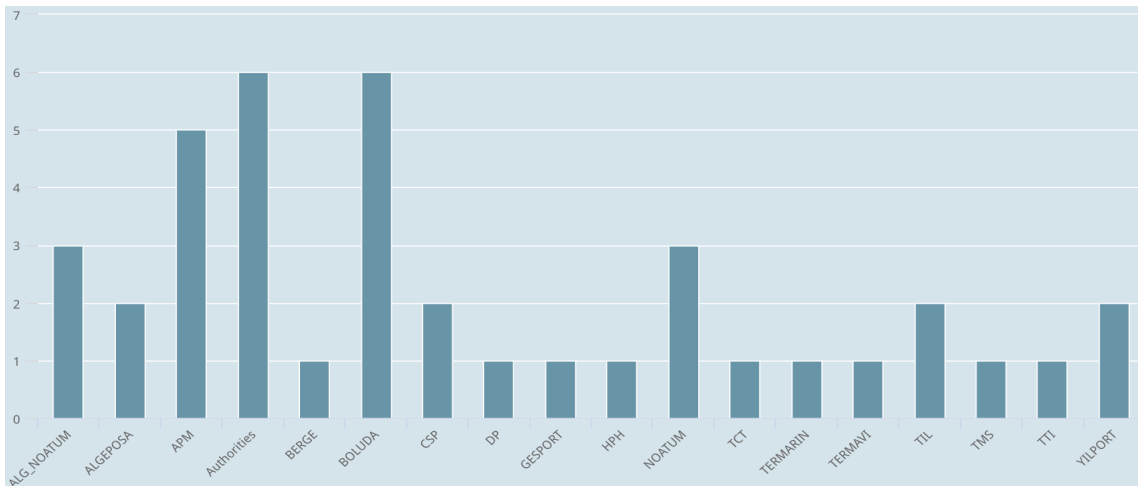


Figure 3.2. Container Terminal Operators Presence and Density in Spain. Own elaboration.

Each container terminal location and its ownership will be seen in the section *substitutes*.

The competition intensity within the industry competitors depends on the following factors:

- High competition result in instability in any market;
- Moderate growth of the industry arises competition for market share;
- High investment costs make competitors to be concentrated on their productivity and efficiency;
- Lack of switching costs is followed by service and price competition.

In the logistics and transport market within the ports we can observe high competition pushed forward by leading companies worldwide and trying to capture the biggest share in the industry spreading their influence on the major ports in strategic terms. Moreover, the investment in equipment, facilities and port automatization in general is quite high so terminal operators are in the constant development of their technologies. This is due to the needs of the terminal and port's capacity to make them more efficient and thus, to gain cost effectiveness. As for the switching costs in this kind of industry, we could conclude that they are quite low as far as it is possible to change to another container operator even within the same port. In addition, the marketing campaigns of all operators are quite developed and could be analysed within the framework of the marketing mix: *Planet, People, Product, Profit, Price, Promotion, Place, and Process* (the 8 P's). (Wiegman et al., 2001)

Planet represents the sustainability of logistic services nowadays: it is possible to find sustainability reports on every terminal's web page. As for *People*, it is considered to be the most important element of the marketing mix as far as the skills of all employees are indispensable to provide a good quality service. The product is service or services provided by the container terminal operators. *Profits* are the outcome of the efficient production process and quality of service provided. The *Price* itself in the logistics industry depends on the contracts signed between both parties, that is, negotiations and service portfolio in addition to the market power of both sides. *Promotion* of the container terminal operators depends not only on personal contacts but also through the internet via advertisement and participation in the business fairs. Furthermore, it goes without saying that the location (*Place*) is crucial for optimal service in the logistics industry. I that

the terminal under the leading companies are located in strategic locations to be able to serve as many locations as possible. As an example, we can see the unique terminals of DP World in Tarragona and HPH in Barcelona as they cover not only the medditerenean coast, but also have good railway connections within Spain. Last but not the least, we encounter with the *Process* itself that plays a key role in the providing the service. It should be carefully planned, including on the agenda the consequent investments on the technological development of the terminal, in which we can highlight the TOS implementation.

Buyers of container terminal operators services

The power of the buyer depends to a large degree on the amount of sales represented by the individual purchaser. The purchaser would strive to achieve the best price-quality partnership for each service, conducting negotiations with various service providers. The power of the buyer depends to a large degree on the amount of sales represented by the individual purchaser. The buyer would strive to achieve the best price-quality partnership for each service, conducting negotiations with various service providers. It has more bargaining power in the case that the supplier has high investment costs in its facilities and the importance of their cost effectiveness is of crucial importance. This is the case for the industry of container terminal operators which are continuously upgrading their facilities and equipment towards a more productive operation (TOS, Machinery, etc.). Recently, we can see more cooperative behaviour among suppliers and shipping companies through the awarding of long-term contracts and the split management of the terminal (e.g., Algeposa+Noatum Alliance). Nevertheless, the competitive environment that exists between key port community members negatively affects long-term cooperation. J. Martin and B.J. Thomas in their study has shown that cooperation has not "necessarily resulted in increased commitment to a long-term future relationship" despite the improvement on the operational level.

Suppliers of facilities

Agents who act as suppliers for the containers market are providers of warehouse (e.g., MSC at the port of Valencia), equipment (TOS, machinery), office (ports and others) and transport suppliers (Renfe and others). In addition to the threat of integrating elements of logistics services into their own service portfolio, suppliers could raise prices, lower the quality of their goods / services provided. Office equipment suppliers, as such, do not represent a particular threat to container terminal operators, but rather to transport companies who are able to incorporate similar facilities into their offerings, thus intensifying competition. Operators are expected, along with automation of the equipment, to invest in or upgrade their TOS. These systems integrate with automation equipment, providing operators with comprehensive control from one united interface over their entire service. Choosing the right provider is difficult for operators, given the nature of the facilities and the associated costs.

Potential entrants

As there are several container terminal operators with the largest influence worldwide, the entry of new companies is very questionable. In terms of Spain, there is a major presence of international APM terminals and a major presence, at the moment, of the Spanish company Noatum as well as

Boluda corporation, whose potential could rather expand or could be acquired in the future by worldwide leading companies or be managed along with them.

Substitutes



Figure 3.3 Substitutes of container terminal operators on the Spanish market. Own elaboration.

Having seen the overview of the main container terminal operators worldwide and its competition intensity, we can proceed to analyse their presence in the Spanish ports as we have previously mentioned, but first of all let us also give an overview of other container terminal operators presented on the Spanish market before continuing on the summary of the global operators' locations presented. As we have already seen there are plenty of substitutes among leading companies worldwide as well as the Spanish companies in charge of the terminals (Figure 3.3). In the following sections we can see all the companies in charge of the container terminals exclusively in Spain and the strategic importance of the terminal and its location.



TTI Algeciras is located at the port of Bahia de Algeciras which is a Spanish leader by container annual volume (by tons) in Spain. TTI Algeciras, the first semi-automatic terminal (Figure 3.4) in Southern Europe and the Mediterranean, began to operate its container terminal on 5 May 2010 with the goal of handling a maximum of 1.6 million TEUs with the gradual start-up of its operations. The terminal is capable of handling state-of-the-art megabucks with a capacity of up to

20,000 TEUs, with an 8-spring crane (STS) unit, 32 automated rail-mounted patio cranes (ASC) and 21 Shuttle Carriers.

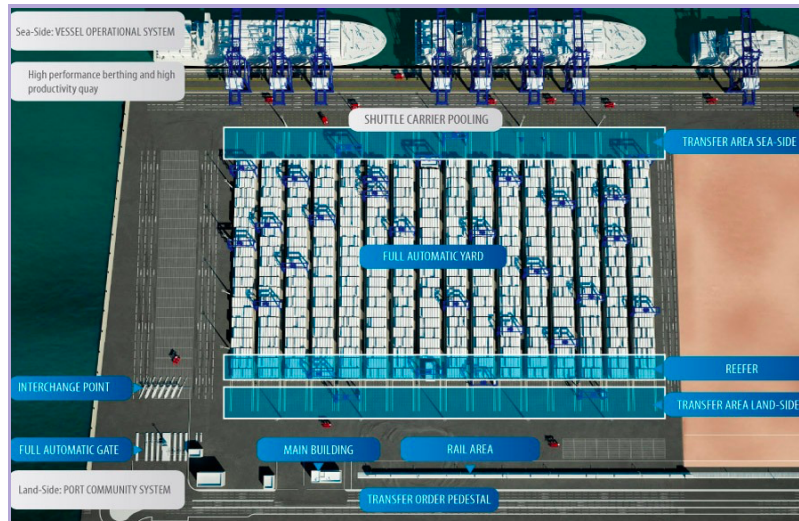


Figure 3.4. Facility map of Total Terminal Internacional (TTI) Algeciras. Source: <http://www.tti.algeciras.com>

Strategic importance and the features of the terminal:

- No divergence from key routes for trade;
- Connectivity that is strong and successful;
- Due to rising import-export traffic, transshipment costs are partially offset;
- The terminal moves nearly 400,000 complete TEUs / year;
- Regular rail service linking the capital (Madrid) and other markets in Spain;
- Highly efficient deep-water berth capable of handling the largest vessels (berth 850 m, 18.5 m draft, STS 23 rows);
- Twin operations and semi-automated positioning;
- Full Automatic Operations by ASC;
- Advanced tools for equipment; Crane information Management System (CIMS), Load Control System (LPS) and Target Position System (TPS);
- Remote exceptions and technical incidence handling (r-CIMS);
- Container traceability of 100 percent by OCR (Optical Character Recognition), RFID (Radio Frequency Identification), RTLS (Real-time location services) and DGPS (Differential Global Positioning System);
- Automatic traceability of containers via RTLS and DGPS Crane driver's technology tools for receiving job orders (VMT in the cabin).



Algeposa started its activity in 1981 as a logistic operator (integral) with the first location established in the port of Pasaia. Currently it has a railway logistics service division that has made Algeposa one of the main Spanish operators in port and rail logistics. The Algeposa group is

presented at one of the critical ports of the Iberian Peninsula and well located, in strategic terms, railway terminals such as Madrid, Barcelona, Sagunto and in the border areas: (Irun-Hendaya, Port Bou and Perpignan).

Algeposa is also a group which is composed by various societies, all of them related to its logistics services. The Algeposa group has 9 port terminals: Castellón, Pasaia, Bilbao, Gijón, Avilés, Huelva, Sagunto, Tarragona, Salalah. As our primary focus are container terminals, we would pay a detailed attention to the 2 container terminals, one of them that Algeposa shares with the Noatum, and their strategic importance as following:

Pasajes (Pasaia)

Ownership 100%. Specialty in steel and forestry products, solid and agri-food bulk products, projects and containers. Acceso y via: Railway for loading/unloading of goods directly from their installations

Noatum Terminal Castellón (Noatum Algeposa Alliance)

Noatum Terminal Castellón provides integrated conventional freight, container and solid bulk facilities. Located in Spain 's largest ceramic production center, the terminal workers specialize in handling delicate loads.



Boluda Corporación Marítima was established in 1837 and started its development as an international logistic operator in 1982. Currently is one of the biggest and the oldest corporations in its sector on the national level. It is a lider in maritime services with a presence in Europe, Latin America, western coast of Africa, Cabo Verde and Indian Ocean. The structure of the corporation is divided in 3 divisions: Boluda Towage (trailer services), Boluda Tankers (for the supply and transportation of fuel) and Boluda Shipping (maritime and land transportation port logistics).

Boluda Maritime Terminals is a subsidiary of Boluda Shipping, a division of Boluda Corporación Marítima and the largest Spanish operator of maritime terminals and container shipping. A division that offers extensive maritime logistics and foreign products management services through its service subsidiaries.

Las Palmas de Gran Canaria

100% ownership. The strategic advantages of the terminal are the following:

- One of the main South-Atlantic logistics platforms;
- Modern terminal, from which the company has been operating for more than 30 years;
- The important point of distribution of goods between the Iberian Peninsula, the Canary Islands and the western coast of Africa, in addition to Cape Verde, Northern Europe and Italy.

Terminal Marítima del Guadalquivir (Sevilla)

Shares the management with the French company CMA-CGM

- Its location provides the logistics platform with excellent intermodal connections by rail and road, through its rail terminal and the SE-30 ring road.

Fuerteventura (Puerto del Rosario)

100% ownership.

- One of the four stowage platforms of Boluda Corporación Marítima in the Canary Islands;
- Proximity to the west coast of Africa.

Villagarcía

100% ownership.

- Boluda Shipping and its traffic with Bilbao, Lisbon and the Canary Islands.

Tenerife

100% ownership.

- Strategic meeting point for freight traffic between Europe, South America and the west coast of Africa;
- Operates 100% of the traffic of the company on the Tenerife island.

La Palma

100% ownership.

- The only container terminal on the island;
- Traffic between the Iberian Peninsula and Canaries.



Port of Las Palmas TIL

100% ownership.

- Location on the intersection of main trade routes;
- Largest container terminal in the Canary Islands;
- Deepwater terminal can handle up to 14 000 TEU vessels.

Port of Valencia TIL

Ownership 100%.

- Mediterranean transshipment hub and distribution gateway for the Iberian Peninsula and Southern Europe;
- Superior connectivity to Madrid's industrial hinterland via toll-free motorway and rail links.



Castellón

Ownership 100%.

- Located in the Spanish tile producing centre;
- The terminal's staff is specialised in handling delicate cargoes.

Cartagena

Ownership 100%. Container traffic is one of the specialties of the terminal.

Málaga

Ownership 100%.

- All types of cargoes in the South of Spain;
- A sheltered port with a nonstop service for clients and great ability to adapt to their needs.

A Coruña

Ownership 100%.

- It has automated facilities and handles containers for local importers and exporters.

In the following table you can see the terminals with the lowest participation at the Spanish market:

Terminal location	Ownership
Marín y Pontevedra	Termarín
Barcelona	Berge
Alicante	TMS
Ferrol	YILPORT
Huelva	YILPORT
Tenerife	TCT
Cadiz	Concasa
Las Palmas	Gesport

Table 3.2. Other terminals with the smallest share on the Spanish market.

Let us turn again to the global leaders of the sector and give the overview of their share on the market. Among the top-10 container terminal operators we can distinguish the presence of the Dutch

APM terminals (part of Maersk):

Algeciras

- Ownership 100%. the Strait of Gibraltar links Asia, Europe, the Americas and Africa;
- Approximately 7% of the volume is dedicated to Import/Export operations;
- One of the largest terminals in the Western Mediterranean.

Barcelona

- Muelle Sur Container Terminal is 100% owned by APM terminals. Manual Terminal.
- It is located on the Mediterranean Coast in the Catalan Region of Spain, in Barcelona, Spain's second-largest city;
- Annual throughput capacity of 2.3 million TEU.

Equipment & Facilities: In order to optimize container handling and function as effectively as possible, the terminal is fitted with the most advanced technologies. Using Optical Character Recognition (OCR) for optimum performance, the automated gates handle over 2,000 truck operations every day.

Castellón

APM Terminals Castellón has an annual container capacity of 200,000 TEUs and accounts for around 70% of the container volume in the Port of Castellón.

- Direct train connections with the hinterland and serves the Mediterranean area, the Middle East and North Africa;
- Activity has increased significantly in the markets around the East and West coasts of Africa;
- In addition to fruit, the area has the largest production of tiles in the world, with 80% of its production destined for export;
- Direct train connections with the hinterland and serves the Mediterranean area, the Middle East and North Africa;
- Activity has increased significantly in the markets around the East and West coasts of Africa. In addition to fruit, the area has the largest production of tiles in the world, with 80% of its production destined for export.

Gijon

- Direct connections to the Atlantic European coast and Canary Islands
- The terminal, with an annual container capacity of 113,000 TEUs, serves Northern Spain

via excellent road and rail links.

Valencia

On 1 May 1999, the TCV Multipurpose Terminal in the Port of Valencia was established. It was founded through the merger of three small stevedoring companies and is located in the Port of Valencia (Spain) at the Levante Pier. Since 2016 it has been acquired at 75% by APM Terminals. The terminal offers a direct rail connection to the Madrid & Saragossa container ports (to the APM and Noatum terminals), near to the distribution centres of major multinationals. For main business customers and additional movements, direct daily trains save extra days of storage. This also helps and saves prices for some commodities, such as the textile industry, export scrap and Spanish agricultural products. Apart of the mentioned above, there are also the following advantages of the Valencian APM Terminal:

- The Valencia region links North Africa and Europe and provides a key link with Latin America;
- The region is connected by road and rail to the rest of Spain and Europe;
- Minimum deviation time from main East-West inter-oceanic routes;
- Hub port for the Western Mediterranean & the West Coast of Africa;
- In the middle of the Spanish Mediterranean, it provides an important gateway to the hinterland, including the Central (Madrid area) and Eastern mainland;
- Easy and fast vessel access from pilot station to berthing position;
- Automated gates with a 30 minute Truck Turn Time;
- Equipment is controlled by means of an automated Global Positioning System (GPS);
- EDI and a customer facing website for real time cargo and vessel tracking.

Other leading container terminal companies which are operating in Spain are DP world and HPH, having under control one terminal each in the following ports with the following strategic importance characteristics:

HUTCHISON PORTS TERMINAL BEST (BARCELONA)

- One of the highest productivity in Europe;
- The first semi-automated terminal in the Hutchison Ports Group;
- The most technologically advanced port development project in Spain;
- Located in the biggest city in the mediterenean;
- More advanced technologically than the APM terminal located in the same port (Barcelona).

DP WORLD (TARRAGONA)

- Excellent road & rail connectivity to Barcelona, Valencia, Madrid and the Spanish hinterland markets like Zaragoza;
- Significant gateway for Spain as well as a Mediterranean hub for global shipping services;
- One of the top 5 ports in Spain;
- Diversified port (transport of vehicles, agricultural products, chemicals, animals and etc).

3.1.1 Recent impact on the industry

The COVID-19 Pandemic

Economies around the world have been disrupted by the pandemic. Due to reduced demand and blank sailings, imports at ports across the world have fallen significantly. For intermodal transport companies and terminal owners, this has contributed to further decreases in container capacity. As regions are struggling to recover, intermodal operators are likely to continue to see decreased demand due to shut down factories on the supply side of the economy and decreased demand-side customer purchasing power. These declines came at a time when, due to economic conditions, the industry was adding capacity to cope with rising import demand. The industry is failing, with little to fill this excess capacity nowadays. (Tideworks, 2020)

The Impact of Brexit


European intermodal operators face their own challenges. The exit of Britain from the EU has contributed to business volatility and unexpected costs.

When shipping goods in Europe, many operators have never faced customs issues. Many smaller operators are struggling to keep up with shipping schedules, with the addition of declarations and inspections. These effects are felt in the system. UK goods are now subject to strengthened controls under France's new strategy, which affects a substantial portion of the freight traffic between the two countries. Delays are growing, leading to a loss of revenue for UK operators (Knowler, 2019). According to the Organization for Economic Cooperation (OECD), the additional administrative and regulatory measures, as well as the delays currently plaguing the system, are projected to increase transaction costs by up to 24 per cent.

3.1.2 TOS Providers

In this section the overview of the main terminal software providers as well the TOS solutions they offer nowadays.

As for the market competition nowadays, we can distinguish the following companies who prevail on the market in terms of digital operations and transactions:

Ranking	Company	
1		Provider of operational technologies and services

2		Provider of terminal operating systems for marine and intermodal terminals worldwide
3		Provider of Stevedoring and Terminal Services
4		A leading marine terminal operator (10nd place in the LLOYD'S ranking)
5		Provider of secure payment solutions (in-store, online and mobile)
6		Infyz provides multiple products on a Cloud based platform for Ports, Shipping & Logistics domain
7		Carrix is a vast global network of multi-modal transport and logistics with the client and we have professional and complementary tasks.
8		Ports America is the largest U.S. terminal operator and stevedore, with regional operations at every major port.
9		Provide a single payment platform globally to accept payments and increase revenue online, on mobile and at the point of sale.



10		Verifone redefines retail by enabling unbridled consumer experience that goes beyond just payments
11		SafetyPay is a non-card payment method with the largest banking network that enables online cash payments, bank transfers and cross-border transactions for the global consumer market.

Table 3.2. Digital operations and transactions leader companies. Source: Owlser.

If closely we focus on the solutions presented on the market nowadays, there is a major use of NAVIS TOS solutions in addition to POSEIDON TOS as it is used by 6 terminals of Boluda corporation and some other terminals all over the Spain in addition to the fact that it is used by some terminals worldwide (in quantitative terms but not in qualitative). Closer look to Poseidon TOS and its customers will be seen in the corresponding section (3.1.2).

Buyers of TOS

The potential buyers are somewhat limited by the decisions of the container operator company as far as the TOS must think in terms of the needs of each terminal. Potential buyers are all existing and on-going Spanish terminals which are still manual or not yet enabled with enough storage to provide container shipment. Many terminals have their proper TOS developed as for example DP

World (TOS Zodiac), HPH (TOS NGEN) and Noatum (own TOS: unknown name) and stay out of potential buyers.

Suppliers

As a supplier of TOS act the proper terminals with their own designed solution or suppliers of the TOS solutions such as Navis and Tideworks. In addition, there is a presence of PACECO ESPAÑA company with its POSEIDON TOS solution and CATOS TOS by Corean maritime logistics solution company Total Soft Bank LTD.

Potential entrants

It is a market which is considered to have an easy entry, however the Navis TOS domain and the fact that it purchased (2019) a recently introduced Octopi (2016) is important as to highlight the control that NAVIS has over the market and the potential to absorb new solutions entering the market. In addition, nowadays have recently introduced 3 different solutions : N4SaaS, Octopi and Master Terminal. With newly presented products, Navis strengthened its already stable position on the market. New potential entrants face some common barriers. First of all, the purpose of the TOS itself is to meet the specific requirements of the terminal in order to make it more efficient. Despite the potential similarities that some terminals could display, they all have their specifications that

must be taken into account when implementing the TOS solution. In order to achieve a suitable level of customer satisfaction, prospective entrants must deliver a solution that will be able to adjust to their terminals, that is, a process review of terminal and port operations must be carried out. In his work, Y. Saanen underlines the importance of the configuration of the correct specifications and of the suitable design for the terminal (Saanen, 2017). Moreover, there is another obstacle which is not only design-related but human error-related. Software solutions such as TOS are able to provide good functionality when the input data introduced is correct and high quality itself. There are still efficiency problems detected when it comes to the TOS functionality which is not related with the software itself but with the input introduced such as the lack of information, its quality or delay.

All in all, we could say that there is still a room for potential entrants but their solution must be innovative enough to compete on the market. One of the last TOS providers introduced by the market were: INPLAN Software Solutions with their ITOS, Cetus Labs introduced web-based TOS Octopi (2016) which was built especially for small to medium cargo terminals and which was recently acquired by Navis (2019). As for the latter mentioned company (Navis) it offers TOS solution N4 itself which is currently in use by APM terminal in Algeciras in it is expected to be installed on other APM Terminals in Spain (currently there is a migration from ARGOS TOS (in-house TOS) to N4 at the APM Barcelona) and already in use by other terminals in Spain (Huelva) as well as at TIL terminal in Las Palmas. Moreover, some of the leading port container companies started to implement their own in-house TOS solutions (DP World, HPH) of their terminals instead of implementing outside TOS solutions such as mentioned and well-known Navis N4. The similar applies to the Spanish company Noatum, which prefers in-house TOS over commercial solutions. Another Spanish maritime logistics corporation Boluda is currently using Poseidon TOS commercial solution by domestic company PACECO Momentum as well as Port Nou in Barcelona and TCT Tenerife.

All in all, it could come as a possible obstacle for an entry as far as some terminals prefer in-house solutions which are specifically adapted to their needs.

Substitutes



Figure 3.5. The substitutes already presented on the Spanish market. Own elaboration.



Figure 3.6. TOS Solutions implanted by Spanish terminals (N4, Catos, Poseidon and in-house solutions) and other leading solutions worldwide. Own elaboration.

As for substitutes we can distinguish two groups: in-house TOS solutions and outsourced TOS solutions.

In-house TOS currently in use by Spanish Terminals	TOS solutions for purchase on the market (Commercial TOS) already in use in Spain and other worldwide leading commercial TOS solutions
Zodiac (DP World) nGEN (HPH) Noatum in-house TOS (unknown name) TTI Terminal in-house TOS (unknown name) ARGOS (Barcelona and Valencia APM Terminals: current migrating to NAVIS) In-house TOS (unknown name) at some APM terminals (Castellón, Gijón, Zaragoza)	N4 (by Navis) CommTrac (by TBA) OPUS Terminal (by CyberLogitec) OPUS Terminal m (by CyberLogitec) GullsEye Hogia Infyz IPortman Oscar Solvo.TOS TerminalControl (by SAAB) TOPS Expert (by RBS) TOPS Expert Cloud (by RBS) U& Terminal Container (by Hyundai Movex's) Octopi (by Navis) ITOS (by INPLAN) Intermodal PRO (by Tideworks) Poseidon (by PACECO Momentum)

	Mainsail (by Tideworks) CATOS (by Total Soft Bank LTD) Navis N4 SaaS Autostore TOS (by TBA) Master Terminal (by Navis)
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Table 3.3. In-house TOS and Commercial TOS solutions. Own elaboration.

It is important to mention that in-house options are only available for the same container terminal company or its subsidiaries.

3.1.3 TOS solutions available for purchase

Let us begin with an overview of TOS solutions provided by Navis, a part of the Cargotec corporation. When it comes to terminal operating systems, Navis is the undisputed industry leader (reference). Navis has a TOS for every terminal, with over 30 years of experience operating with leading terminal operators. The Navis portfolio of terminal operating systems ranges from Octopi for small and medium-sized terminals and to the industry standard N4 and N4 SaaS TOS in addition to the TOS Master Terminal which operates terminals of all sizes and freight.

Octopi (by Navis)

Octopi was especially designed by small and medium cargo terminals. The following advantages of this software could be mentioned: gate and yard management, damages and repairs control, stowage planning, real-time key performance indicators and automatic reports issue in addition to electronic data interchange (EDIFACT and ANSI x 12) and automatic invoicing. As for disadvantages, the cost involved in the subcontracting and of the adaptation of the system to a certain terminal. performance indicators (automatic reports issue). Among other advantages we can distinguish the following:

- Cloud-Based, simple Software as a Service pricing ;
- Easy-to-Use Interface;
- Accessible from any device and anywhere;
- Real-Time KPI & EDI Dashboard and Analytics (Image N Dashboard example);
- Quick Implementation Time;
- Enhanced digital and Physical Security;
- Continuous updates and improvements;
- Unlimited users and roles;
- Software Built to Fit Niche Operation;

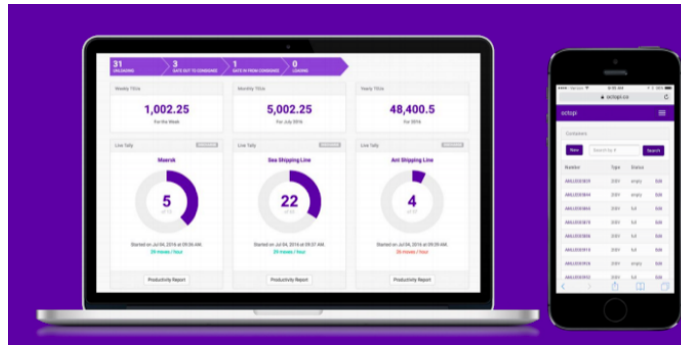


Figure 3.7. Octopi TOS interface on different devices. Source: blogpost How Octopi Makes a Terminal Operating System Productive. Website: medium.com

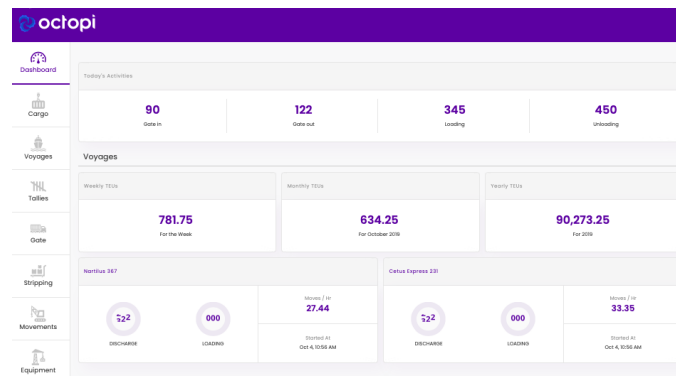


Figure 3.8 Octopi TOS dashboard. Source: <https://octopi.co>

N4 (by Navis)

- The only TOS that supports multi-terminal operational visibility and control;
- Permit to avoid expensive customization and tailor N4 to meet specific needs with system options which involve advanced configuration, customization and integration;
- Advanced EDI options: An revolutionary approach to EDI management with a highly configurable and accessible EDI format that greatly reduces the amount of on-going maintenance;
- Mobility Execution Options offer real-time monitoring and management of all equipment;
- Planning and management of facilities;
- The XPS client framework provides real-time features that provide world-renowned operational efficiency and productivity;
- A full set of modules for optimization assists in automating decisions and enhancing performance and productivity;
- Optimized Container handling and yard utilization, Vessel planning, crane scheduling and monitoring;
- Reduced Administration and Support cost: Automated Terminal Option supports unmanned technology, such as automated equipment;
- Advanced Rail Options provide advanced rail service control and management;
- A holistic approach to streamlining operations is taken by N4 optimization modules to

ensure that ground, labor and equipment are used in the most efficient way. Optimization Modules include Expert Decking, PrimeRoute, Vessel Autostow, and Rail Autostow;

In Spain, currently in use by: Las Palmas TIL terminal (OPCSA), Barcelona APM and Valencia APM Terminals(at the moment migrating from ARGOS), Yilport Terminal Huelva, CSP Valencia, Algeciras APM).

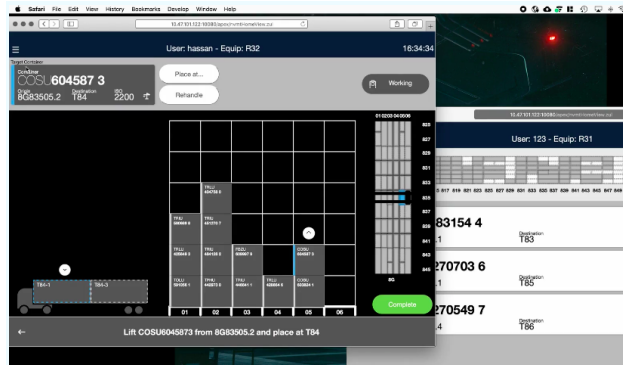


Figure 3.9 Container control in real-time in NAVIS N4. Source: Demo presentation available on <https://www.navis.com>

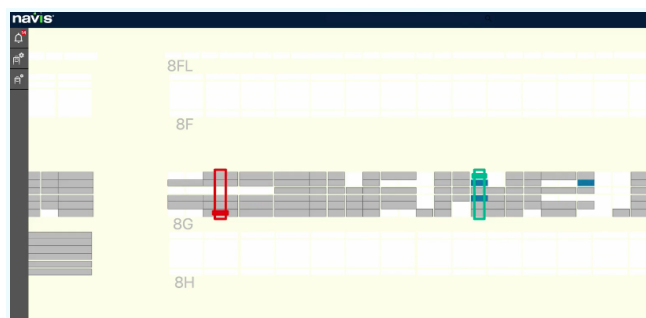


Figure 3.10. Navis N4 Application. Source: Demo presentation available on <https://www.navis.com>

N4 SAAS (by Navis)

As the Terminal Operating Systems (TOS) market pioneer for over 30 years, Navis continues to lead and forge new innovations with the launch of N4 SaaS.

N4 SaaS is a cloud-based TOS that provides all of N4 's functionality without the costs and difficulties associated with installing , maintaining, and handling it. N4 SaaS has the advantages of extensibility, configurability, function and function richness, but has made it easier and more cost-effective. Modern cloud technology has advanced to a point where almost everywhere in the world we have real-time responsiveness for any form of service.

In a nutshell, the following advantages can be seen of N4 Cloud based alternative N4 Saas:

- Decrease of the expenditure on the physical infrastructure thus increase of profit margins;
- N4 SaaS flexibility which allows to scale up and down the capacity as terminal grows;
- Competitive advantage by giving the customers a customer-centred experience in form of innovative applications;
- Allows the terminal to have real-time access to new features as they built instead of waiting periodic upgrades for on-prem solutions;

- Possibility to move your TOS partially on cloud or completely. Navis is compromised to guide the terminal through its cloud transformation;
- Customers of Navis N4 who have made the transition to Hosted N4 reduce their operational costs by up to 30 per cent;
- Enabled for terminals of any size and on any edition of N4.

Master Terminal (by Navis)

- Yard operations with performance indicators;
- Mobile applications;
- Rail operations control in real-time, graphical views of the train, automatic load and discharge;
- Gate operations manageable from any device;
- Reporting in different formats such as CSV, PDF, XML OR HTML;
- Mechanisms for interfacing to a third parties including EDI, file report, web services, SQL, real-time TCP/IP connections;
- Automatic Invoicing;
- Auto-planning warehousing options;

Mainsail (by Tideworks)

- Minimum IT expenses with Tideworks' hosting, EDI management and integration services;
- Intermodal terminals optimize equipment utilization with the intermodal TOS that plans train loading in a single click;
- Flexible and highly-configurable TOS solution with the access to third-party integrations such as ERP (Tideworks developed open APIs and the billing service is integrated in the solution);
- Transparent sales support;
- User Interface (Image N);
- Dynamic Recap Feature (Image N);
- Different theming (Image N) and iconography;
- Zoom controls (Image N);
- Adapted for different devices: tablet as well as a compute.

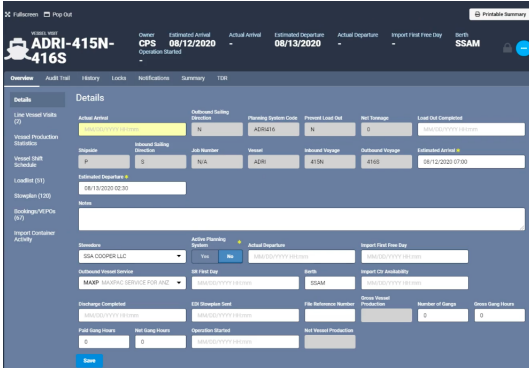


Figure 3.11. User Interface of Mainsail TOS by Tideworks. Screenshot taken of the video presentation of Mainsail TOS on the official Tideworks website.

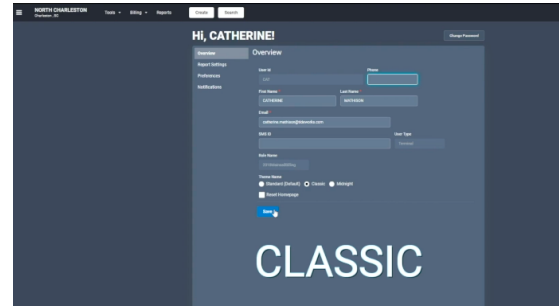


Figure 3.12. One of the themes of the Mainsail TOS. Screenshot taken of the video presentation of Mainsail TOS on the official Tideworks website.



Figure 3.13. Dynamic Recap Feature. Screenshot taken from the video presentation of Mainsail TOS on the official Tideworks website.

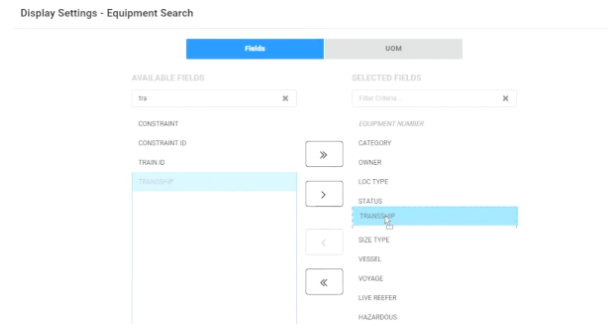


Figure 3.14 Equipment Search. Screenshot taken from the video presentation of Mainsail TOS on the official Tideworks website.

Intermodal PRO (by Tideworks)

- With color-coded views, customizable lists, and single-click data recaps, it is possible to view key data at a glance;
- Save time and the capacity to save searches for repeated use with a solid Find Tool;
- Run customizable reports effortlessly;
- Maximize yard usage and estimate parking stall and decking allocations automatically;
- Pick the optimal position when a unit is unloaded using the "just in time" feature for yard planning;
- Use the "live lift" feature to direct incoming gate traffic based on configurable rule sets to trackside locations;
- Set up loading rules and train routing in a single click for load schedule rail cars;
- Improve the use of machinery with simultaneous load and unload planning

- A proprietary integration module designed for this purpose simplifies communication between Intermodal Pro and third-party systems;
- Automated load planning;
- Inventory Management;
- Gate operations;
- Assessment & Execution of Switch Strategy;
- Electronic Data Interchange (EDI):
- Actual and planned Cone States;
- Just in Time Yard planning;

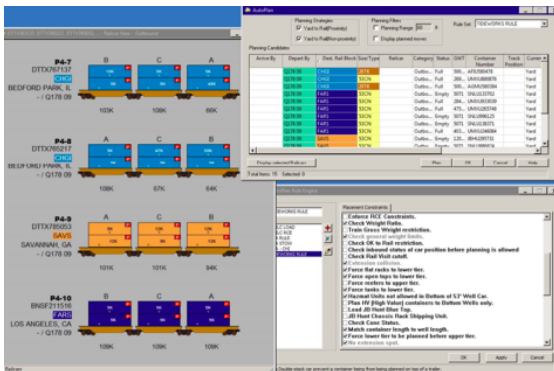


Figure 3.15. Graphical Planning (Intermodal PRO). Screenshot taken from the Intermodal PRO product sheet downloaded from the official Tideworks website.

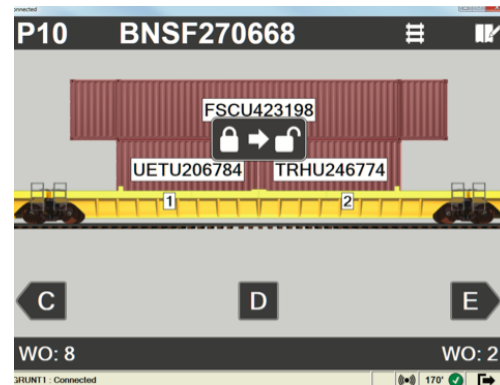


Figure 3.16. Traffic Control. Screenshot taken from the Intermodal PRO product sheet downloaded from the official Tideworks website.

Poseidon (by PACECO ESPAÑA)

- Customised adaptations, training and maintenance as a key;
- Implementation until it works at full;
- Gate and Yard management;
- Container Positioning Implementation;
- Machine Management;
- EDI files management;
- Bidirectional website (real-time);
- ERP terminal module (Automatic invoicing).

Disadvantage: no 3D Visualisation and Simulation modules for container positioning and movements (Terminal Smart Vision); no cloud platform, no KPI dashboards.

In Spain, currently in use by: all Boluda terminals in Spain, Concasa Cadiz.

CATOS (by Total Soft Bank LTD.)

Intelligent Optimized Planning System: Berth, Yard and Ship (Image 3.17) planning

- Real-Time Planning;

- *Doble Cycling and Yard Tractor Pooling;*
- *Category Loading;*
- Berth Monitoring System and Terminal Monitoring System (Image N);
- Vehicle Mounted Terminal (VMT) and Hand Held Terminal (HHT): Radio Data Transmission (RDT) Terminals are available for customers in case of operational and technical needs and CATOS supports both Text based and Graphic based terminal of VMT and HHT. RDT terminal programs with a strong Graphical Interface (Image N) are practical and simple to use;
- C3IT(Command, Control, Communication and Intelligence) Server-application that controls every operation within container terminal;
- On-line Analytical Processing (OLAP) provides strategic information of any duration that could be chosen by a user. It is possible to download reports in any kind of formats including Text, MS Excel and PDF;
- Customized billing system;
- Operation Management program which can receive data in form of EDI, e-mail, fax or via Web (all these options if received in electronic version can be directly uploaded in the program, in case of fax there is a possibility of data entry). The information contained in the operation management program will be shared between all CATOS systems. Also includes Web-IP and CATOS EDI mapping which supports various EDI formats including UN/ EDIFACT.

In Spain, currently in use by: Valencia MSC terminal (TIL group)

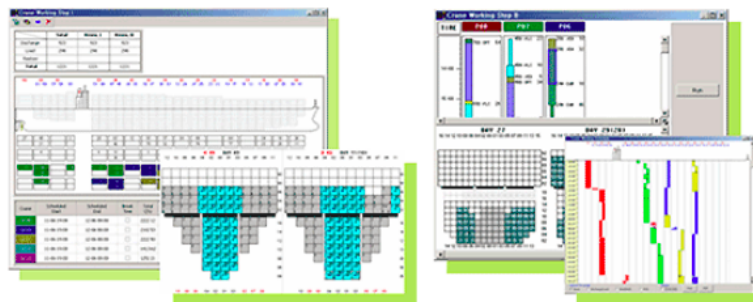
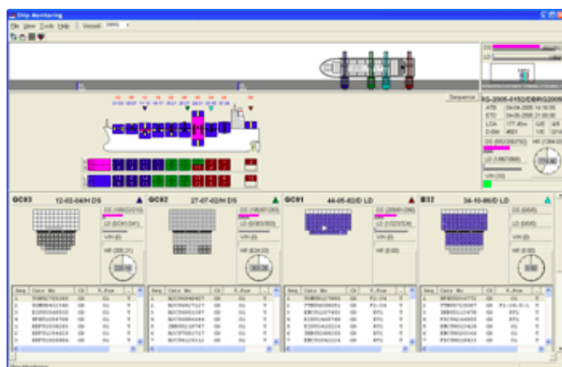


Figure 3.17 Auto Ship Planning by CATOS. Image retrieved from the original website of the Company Total Soft Bank LTD.



the original website of the Company Total Soft Bank LTD.

Figure 3.18 Berth Monitoring Screen-Ship Operation by Catos. Image retrieved from

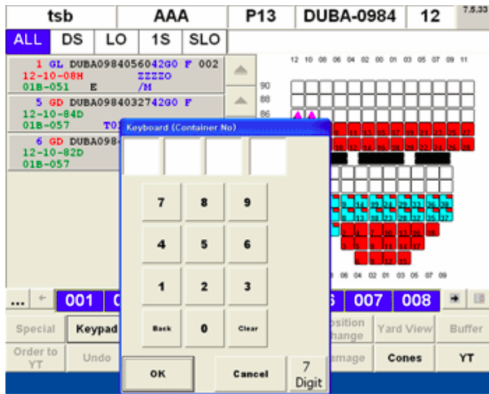


Image retrieved from the original website of the Company Total Soft Bank LTD.

Figure 3.19 Graphical User Interface.

Disadvantage: user interface

Autostore TOS (by TBA)

Autostore TOS is built for Port, Inland, Yard operations and Advanced Equipment Positioning. It monitors in real-time all container movements, manual and automated assets, individuals and management data through single or multi-terminal sites. Autostore is fast and intelligent with built-in equipment control functionality, and is able to efficiently integrate with all third-party business ERP systems. Autostore is the container terminal management system that could be based on cloud or locally installed, offering a dynamic, real-time inventory management in all areas of terminal operation, highly scalable and with a flexible, open architecture (Figure 3.20).

- For all types of coastal, inland or riverine ports, entirely customisable or off-the-shelf;
- A wide variety of smartphone applications for use on rugged personal computers;
- Seamless integration for multipurpose terminal terminals with the CommTrac bulk and break bulk TOS solution;
- Dynamic Vessel Planning: easy to use drag and drop functionality and auto planning, which allows to significantly reduce vessel planning time;
- Equipment utilization: reduces idle and non-value - added time for equipment by efficient preparation and execution of movements and work of equipment;
- "Future-proofing performance": improves productivity, reduces costs, improves profitability, eradicates accidents and optimizes capital for high performance to future-proof the cargo handling businesses;
- Vehicle Booking System: reduces truck / gate operations peaks by streamlining turnaround times and arrival times for vehicles.

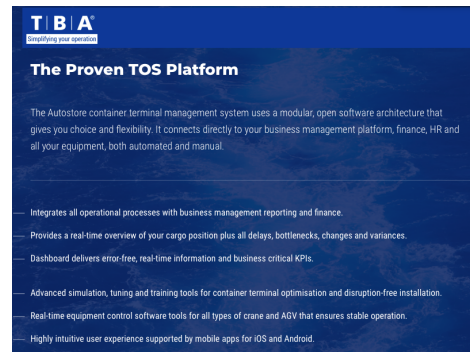


Figure 3.20 Autostore TOS functionality summary. Source: Image retrieved from the official website of the TBA.

CommTrac TOS (by TBA)

Non-containerized cargo handling is optimised by the CommTrac bulk terminal operating system (TOS). In real-time, it links the manual and automated properties, people and management data through single or multi-terminal sites.

- Integrated strategy with respect to the stakeholders' connection: Incorporates terminal data for enhanced decision-making through management , planning, oversight, operations , finance and business clients;
- Performance improvement: Optimized preparation and superior installation of equipment eliminates demurrage charges and optimizes the head count.

OPUS Terminal (by CyberLogitec)

The OPUS Terminal by CyberLogitec is an optimized terminal operating system (TOS) that ensures exceptional versatility and scalability for terminal operators in order to meet the extreme operational requirements. OPUS Terminal integrates the roles of planning, processes, EDI, and KPI (Key Performance Indicators) Dashboard analytics to cover the range of terminal operations and to connect various equipment and systems. This seamless summary offers useful organizational efficiency intelligence across the entire port. Features:

- TLS (Terminal Logistics System): A complete system for asset management that streamlines work queues of equipment based on individual workload;
- Advanced Vessel Planning: Monitors operational priorities such as IMD(International Maritime Dangerous Goods) and destination port, appropriately schedules and allocates containers inside the vessel to particular slots;
- Advanced Yard Allocation: Depending on the vessel's storage position, the yard's work queues and available work levels, the allocation of containers inside the yard is prioritized;
- Global Truck Pooling: Optimizes the travel distance and waiting time by allocating vehicles for best possible pooling of equipment through activities by optimizing travel paths intelligently to reduce congestion;

- Graphical VMT/PDA: Graphical-based UI devices to enable task management for equipment (Vehicle Mounted Terminals) and operational staff (Personal Digital Assistants);
- Internet of Things (IoT) Ready: A range of remote positioning protocols, such as RFID/DGPS/INS/PDS, are supported by the system.

Disadvantage: no 3D/2D Visualisation and Simulation modules for container positioning and movements (Terminal Smart vision); no cloud platform.

OPUS Terminal M

OPUS Terminal M is an advanced terminal operating system for multipurpose terminals. Its capacity to handle all forms of cargo vessels, including container, bulk, RORO, barge and rail and truck transport, designed especially to meet the increasing needs of terminals. **Featuring 2D and 3D virtual terminal** yard views, accessible in a single instance while handling all aspects of terminal operations in real time. OPUS Terminal M is highly customizable and can be conveniently deployed on premise or on the cloud. Its JAVA and HTML5 architecture allows all main browsers and mobile devices to access the solution.

Features:

- Data Collaboration: synchronised data flow to streamline communications. Shared data enhances the level of precision and speed at which terminals run in addition to the reduction of duplicated data and visibility increase;
- Terminal Operations and Management: maximises operational efficiency by centralising processes in handling cargo, statistics tracking, data analytics and performance reports. Management of cargo effectively in different types of storage facilities. Establish versatile internal operating procedures focused on the management of business processes;
- 3D Virtual Terminal Smart Vision: Enhances the transparency of the activities. In the next generation of terminal operations, 2D and 3D views of the terminal are key. With full real-time visibility of yard activities, the solution shows cargo properties along with zoom functions that provide critical data to quickly support business decisions. This feature provides details with zoom functions to gain greater clarity to yard activities and enables staff to closely monitor the operations in a safe way;
- Advanced container terminal functions: planning time is minimized with dynamic features that evaluate alternatives and requirements in addition to enhanced user experience (functions represented in a single window). Moreover, the tasks, processes and workflows are automated.

GullsEye

GullsEye is a terminal operating system that accelerates the service of container, ro-ro, general cargo, liquid cargo services in terminals. With advanced monitoring and reporting

modules, GullsEye ensures customer satisfaction and provides comprehensive readability. The following features could be distinguished:

- **Powerful Optimization:** create an optimal operations plan by using the equipment and resources efficiently and locating the containers in the right place for the gate.
- **3D Monitoring & Design:** managing a terminal in a 3D environment (Figure 3.21). The monitoring includes: container tracking, cranes and track management, vessels at berth monitoring;
- **Efficient planning (Figure 3.22):** organisation of yard and berth operations, planification of vessel loading, discharging and shifting operations;
- **Operation:** just in time work orders for cranes, trucks, weighbridges and gates (with a possibility to start, pause, cancel and also simulate operations);
- **Trade & CRM (Customer Relationship Management):** definition of services, customers, agencies, liners and subcontractors; quotations and contracts management; automatically generate customer invoices;
- **Management:** accurate and up to date data with KPI dashboards which allows to control the costs, revenue and profitability even from a mobile application;
- **Easy integration with other systems** such as ERP, Gate Automation Systems (ALPR, OCR, RFID), EDI (COPARN, COPRAR, CODECO,VERMAS, BAPLIE) and Equipment Integration (RTG Smart-Rail, Reefer measuring, Weighbridge);
- **Self-Service Solution (Web application (Figure 3.23), IOS (Figure 3.24) and Android):** allows a user to follow yard & vessel operations and container requirements, inventory control, storage cost calculation, weighbridge receipt or damage registration forms, the possibility of payment of terminal fees with commercial internet banking;
- **Cloud application support.**



Figure 3.21 3D Monitoring and Design in GullsEye TOS. Source: www.gullseye.com.

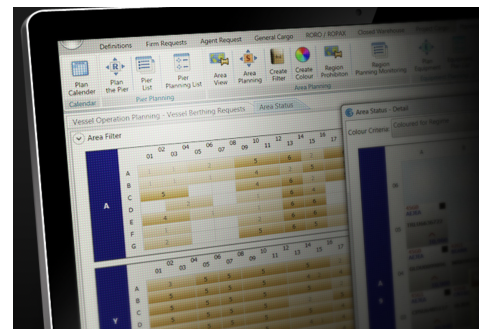


Figure 3.22 Vessel operation planning in GullsEye TOS. Source: www.gullseye.com.

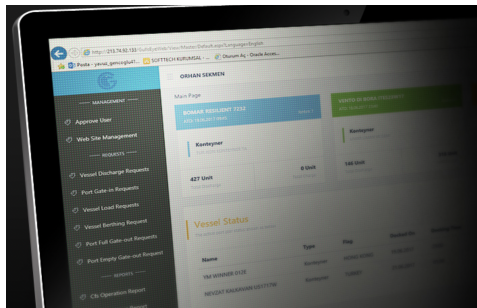


Figure 3.23 Web Application of GullsEye TOS. Source: www.gullseye.com.

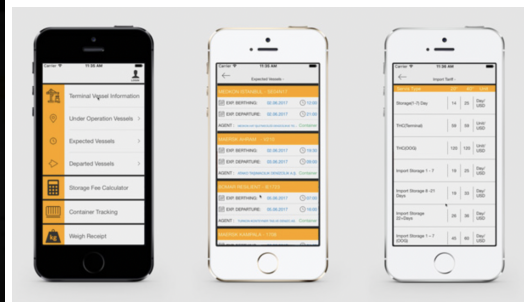


Figure 3.24 IOS Application of GullsEye TOS. Source: www.gullseye.com.

Hogia

Hogia is a standard product with new releases several times a year on the basis of customer requests and requirements. Hogia TOS is based on Microsoft products, which provide a robust platform with easy installation and configuration that keeps the costs down to a minimum. This TOS solution core includes the following applications: bookings, EDI, automated invoicing, monitoring (as to act on potential bottlenecks), operational handling (operational work performance using smart phones and tablets), yard planning. As for additional features of the Hogia TOS, the following could be mentioned:

- API: a possibility to connect TOS solutions by remote access, providing the reliable real-time information in a standardised format;
- Terminal Map: visualization of plans and yard organization as to maximize the assets and capacity in real-time;
- Gate solutions: reduce the stop time of the driver at the gate-in by introducing a fully or semi-automated system;
- GPS: avoid misplacement of units through GPS-coordinate positioning;
- Inspection: ensure the condition of arriving and departing units;
- Reports and KPIs dashboards;
- Verified Gross Mass: verification of the unit weight in accordance with the safety of life at sea (SOLAS) and effortless customs clearance;
- Depot Handling: Effective operating workflows for as few stack lifts as possible;
- Rail Planning: enables easy planification of the positioning of wagons and units in the train set.

Disadvantage: no cloud platform; no integration with ERP

Infyz

Infyz is a provider of multiple products on a cloud based platform for ports, shipping and logistics. Infyzs TOS is designed for handling container terminals. The system was implemented with one of the internationally renowned partners of the PSA Group, KCPTL

Kakinada. It supports EDI, Vessel Auto Stow, Pre-Yard Planning, Crane split and Sequence Generation. The following advantages are presented:

- Advanced design features of the vessel, yard and stow including auto stow functions for greater reliability;
- Built in interfaces for automating port equipment and gate controls;
- Ability to plan a ship for the entire voyage with automated control of possible conflicts in upcoming ports;
- Efficient tools for sorting, filtering, grouping, organizing and processing container lists and generating various reports;
- Containers can be loaded, rearranged and removed at any selected port with the results of these changes automatically forecasted for all transit schedule ports.

Disadvantages: not user friendly interface compared with the market leader navis and its solutions as Navis and Octopi (provides an interactive dashboard); no cloud solution; No 3D Simulation; no integration with ERP

IPortman

The iPortman Terminal Operating System (TOS) manages the operation of the container at the berth, yard and gate. It includes all types of containers intended for import, export and trans-shipment operations. The key features are the following ones:

- The iPortman TOS reads and shares EDI messages of all types. Messages may be related to the vessel, cargo, container, gate or billing – including IFMAN, BMISRM, HANMOV, COPRN, COPRAR, COARRI, CODECO, COPINO, COREOR, COSTOR and so forth;
- It offers an all-in-one solution for the operation of vessels, loading or unloading operations, operation of yards, operation of gates and billing operations and enables an effective planning;
- Multiple container handling devices such as STS cranes, straddle cranes, conventional quay cranes, mobile harbor cranes, reach stackers, TTU's, shuttle carriers, AGV's, RTG cranes, RMG cranes, OHB cranes and other preferred cranes in the industry can be incorporated into the system;
- The mobile application can be deployed, allowing data to be transmitted more easily and accurately. Its temporary storage system also helps operate in an offline mode.

Disadvantages: not user friendly interface compared with the market leader navis and its solutions as Navis and Octopi (provides an interactive dashboard); No CRM module; no cloud solution; No 3D Simulation.

Oscar

A single interconnected, real-time view of all operations and data is provided by the OSCAR TOS, allowing to make smarter decisions faster, resulting in increased productivity and operational performance. Depending on the latest situation in the terminal, missions are always described. For complete control, a full history of the terminal operations is also available. The key features of the OSCAR TOS are the following:

- Real-time key performance indicators: OSCAR enables a user to monitor key output and optimize operational efficiencies from many dashboards and on a scale mapping combined with real-time GPS or DGPS (Differential GPS) equipment monitoring;
- Berth and Vessel planning: enables modelling, view and handle different sequencing scenarios to create the most efficient crane split on the terminal automatically. It is possible to choose the best solution based on the number of devices used, the charge and length of the balance process, choose the best algorithm to fit one's requirements (fastest solution, most balanced solution, etc) and extract data needed;
- Yard Planning: visualization on an interactive map of containers and equipment. Easy search for containers which provides the view of the current and on hold processes on the dashboard;
- Gate Planning: OSCAR integrates an online appointment module which allows to share a timetable directly from the Internet with truckers for the receipt and delivery of containers. It simplifies traffic at the terminal, reduces peak times and improves the efficiency;
- Electronic Data Interchange (EDI): With OSCAR, EDI messages are received, submitted and processed. This TOS allows exchanges according to common formats (COARRI, CODECO, VERMAS, etc.);
- Cloud-based platform: OSCAR is a cloud-based app that can be used anywhere, anytime: online access and a computer, tablet or smartphone. Furthermore, by allowing a user to save a copy on its secure servers, its DRP Disaster Recovery Plan protects the terminal's data from any loss.

Solvo.TOS

A comprehensive terminal operating platform to handle ports and terminals of any kind in real-time process and business activity: maritime and inland containers, multi-purpose, bulk and Ro-Ro. The modular nature of the device enables the desired features and SOA (Service Oriented Architecture) to be carefully chosen - to easily integrate the solution with different 3rd party applications and hardware. The advantages of this solution are:

- Universal Vessel Stowage Planning & Control: algorithms for crane sequencing, automatic filling and conversion of EDI messages bay plans, stowage planning for marine containers, 3D vessel layout editor (Figure 3.25). Available in fully-automated, semi-automated and manual modes;
- Real time reporting (Figure 3.25): set of preconfigured reports, customizable, embedded module or generating reports via [SAP Crystal Reports](#);
- Electronic Data Interchange (EDI): supports an entire EDIFACT messages spectrum, csv and xml messages and automatic conversion of corresponding messages from the line into a bay plan;
- Can be integrated with third party solutions such as ERP, GOS, PMIS and many others through a set of predefined application interfaces (gateways).

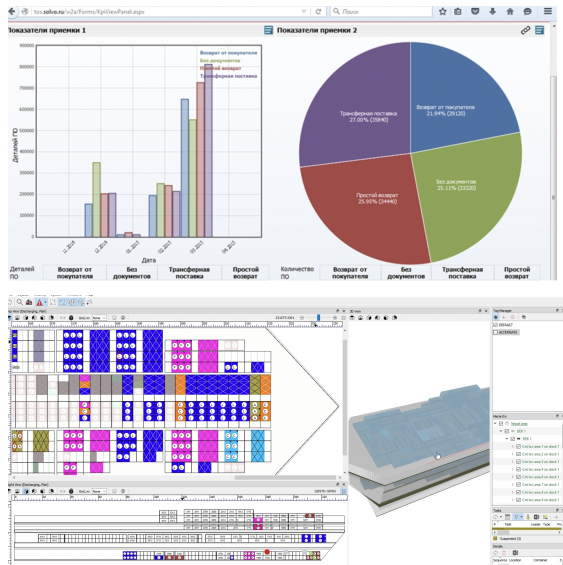


Figure 3.25 Slovo TOS dashboard. Source: <https://www.solvo.ru>

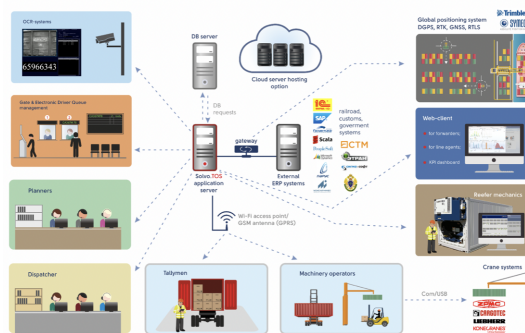


Figure 3.26 Slovo TOS framework.

Disadvantages: not user friendly interface compared with the market leader Navis and its solutions as Navis N4 and Octopi (provides an interactive dashboard).

Terminal Control

One of the few in the world that fully supports multi-purpose terminals, handling break-bulk, bulk, general freight, roll-on roll-off, and container cargo is the TERMINALCONTROL TOS by SAAB. All in one user-friendly package (Figures 3.27, 3.26). The following advantages can be listed:

- Highly customizable device design that can be easily modified by the end user, including improvements in the layout of the yard, warehouse space and usable berths. Similarly, for instance, the consumer can change or add business rules for tariffs;

- The functionality of yard planning would ensure that the incoming cargo is planned in the most suitable location and that the terminal has a complete graphical overview of the actual cargo positions in the yard;
- The equipment control module: ensures that a well-placed equipment driver performs any expected movement. TerminalControl can create a stowage plan based on information from different sources when a vessel needs to be filled.

<p>Order Management</p> <ul style="list-style-type: none"> • Waterside orders: discharge and load lists • Landside orders: delivery and receipt • Special orders: stuffing and stripping • Applicable to containerised & non-containerised cargo 	<p>Vessel Operations</p> <ul style="list-style-type: none"> • Registration of planned vessel calls • Time recording, e.g. ATA/ATD, start/end of operations and delays • Vessel discharge and load tally • Statistics
<p>Gate Operations</p> <ul style="list-style-type: none"> • Truck/Train/Barge pre-arrival notifications • Gate-In/ Gate out for truck, train and barge • Truck/Train/Barge tally 	<p>Yard Management</p> <ul style="list-style-type: none"> • Cargo registration at yard positions (open storage areas, container stacks, and warehouses) • Automatic yard planning and visualisation (Yard View) • Cargo transfer tallies
<p>Special Handlings</p> <ul style="list-style-type: none"> • Stuffing & stripping operations • Registration of other special handling, e.g. cleaning, fumigation, for invoicing purposes 	<p>Technical</p> <ul style="list-style-type: none"> • Microsoft .NET Framework • MS/SQL or Oracle database • Client application & web based front end for data entry by external parties (agents)

Figure 3.27 TERMINALCONTROL Features. Source: <https://www.saab.com/products/terminalcontrol>

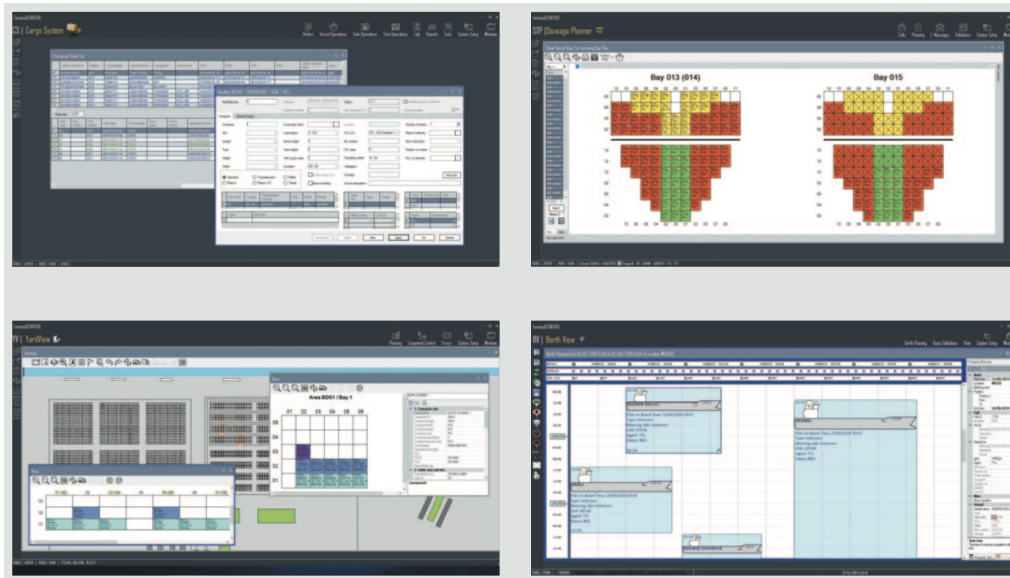


Figure 3.28 TERMINALCONTROL. Interface and modules (cargo system, stowage planner, yard and berth views).

Disadvantages: no 3D visualization and simulation, absence of automatic generated reports and KPIs dashboards (at least not announced as such).

TOPS Expert

Realtime Business Solutions specializes in the development and deployment of the TOPS Container Handling Industry TOS. RBS also offers shipping and rail container handling industry consultancy services, develops specialized state-of-the-art container handling

software and carries out the installation and implementation of its Terminal Operating System (TOPS). With the incorporation of improved technology that offers a variety of terminal management capabilities by analyzing 'Big Data', its system architecture is further enhanced. Its key features are depicted on the Figure 2.6. which are quite complete and similar to

previously mentioned TOS packages. Nevertheless, the following advantages must be mentioned:

- An integrated heuristic algorithm that allows the system to manage data using 'big data' analysis;
- Reporting Tool: PDF capable reporting tool integrated into the TOS as well as a standard export interface to programs such as Microsoft Excel;
- New Automated Search: A robust and useful search feature has been implemented by TOPS Expert, which considers all available information sources to produce results faster;
- Internet of things (IoT): TOPS Expert links terminal equipment, computers, and system networks to support a range of remote positioning protocols such as RFID and DGPS (can be used for automation);
- Quicker Navigation: brings a brand new interface which is easier to use, displaying in a clear and easy-to-use layout the most important details;
- Operational Visibility: the intuitive TOPS Expert user interface supports the ability to schedule, track and forecast in real time, enabling terminals to respond quickly and plan for upcoming situations.

Figure 3.29 TOPS Expert. Dashboard.



Disadvantages: user interface is not modern and could be renowned as for example octopi solution has and make it more intuitive.

TOPS Expert Cloud

TOPS Expert Cloud includes a comprehensive suite of terminal management capabilities of previously mentioned TOPS Expert, including optimization of operations; yard management; vessel management; berth management; crane allocation; management of container handling equipment; gate management; financial systems reporting and interfaces, Gate

Operating Systems, REFCON (reefer monitoring system), radio data terminals and GPS systems. The following advantages can be distinguished:

- Scalability: allows unlimited expansion of operations as to meet the growing demand on container traffic, new customers and information from different sources;
- System architecture: The cloud framework utilizes TOPS' unique system architecture and allows easy remote access from any browser. This enables a very transparent

approach to the incorporation of other systems or resources using web services to communicate. The infrastructure is delivered by PaaS (Platform as a Service).

U& Terminal Container

U& Terminal Container is a terminal operating system developed by integrating the know-how of the global shipping company Hyundai Merchant Marine's terminal operations with HYUNDAI MOVEX's state-of-the-art IT technology and, as such, is the solution with the largest market share of terminal operating systems in the domestic market (Corea). The key features and advantages of this solution are:

- Automation Module: Due to full automated crane and yard crane control API, and as an independent module, can be connected to a manual TOS;
- Module for optimum equipment position provision that takes yard conditions into account in real-time (Auto grounding system);
- Integrated monitoring & control functions of terminal operations (3D visualisation feature);
- Functionality of real-time monitoring for unexpected scenarios (disaster prevention);
- Customer Management: E-Services (provides a vessel/shipping company/customs EDI portal and an EDI engine).

Disadvantages: no cloud solution; No 3D Simulation: unknown compatibility with other ERP; No automatic billings; no KPIs dashboards.

Chapter 4

Methodology

The following section describes the search, collection of data and review process of scientific publications dealing with the functionality of container terminals as well as the performance, sustainability and automation of the port facilities. In addition, the search was not limited to scientific papers published in journals, but to obtain better knowledge of some of the relevant concepts and state of the art, various master's and doctoral theses were revised. With the exception of a few articles and publications that were used to compare the success of recent research, the literature quest was limited to publications published between 2014 and 2020. The time-frame was also restricted to include publications that better represent the existing port automation context, its sustainability, as well as the container port operators and terminal operating system solutions currently offered on the market and its choice criteria. Furthermore, qualitative data analysis was carried out in the form of content analysis based on the answers of the port authorities, the container terminal operators and the relevant information provided on their websites and on the portals of the suppliers of terminal operating systems. As for explorative analysis itself, it was seen in the literature review section (chapter 2) that there is a certain lack of the scientific papers dedicated precisely to TOS solutions apart from the 2 recent ones, which developed on TOS functionalities and the main companies on the market were described. Other scientific articles, these topics were described quite briefly and information on TOS, its functionalities, positive impact on the terminal development, digitization of the services and the existent solutions on the market was quite scarce. Taking into account that the topic of the present thesis was not widely investigated, the exploratory analysis of the latter was proposed which would help to analyse the state of the TOS solutions market and different terminal operating companies share in Spain.

Apart from explorative focus, the following approaches were taken to elaborate the present work: descriptive, quantitative, qualitative and empirical. As for the descriptive and analytical approach of the exploratory analysis mentioned previously, it could be said that, from the one hand, the descriptive approach includes the surveys and inquiries to the port authorities, terminal operating companies and TOS providers. Quantitative approach consists of measuring the quantity of existing terminals themselves and the TOS in use by them: the count of terminal operating companies and its share on the Spanish market and the TOS implemented (commercial TOS count and in-house TOS count: Figure 5.1) . Moreover, the different objectives are approached (as tos count) as well as the questions associated with the current topic are studied as for example the relation between sustainable development goals, more importantly TOS implementation as means to support the digitalization objective, the quantitative relationships between descriptive variables of different factors of the study such as: Location(city/coast), TOS Implementation (yes/no; name of the TOS

solution), Terminal Operating Company (Name) are determined and the possible correlation between variables have been studied using R software for data preparation and then processed in Python using pandas profiling module as to perform exploratory data analysis. In addition, the qualitative aspect was also considered as far as not only the share (in terms of the quantity of terminals) of terminal operating companies are important, but also its input in terms of the volume of containers/ tons of goods received (e.g., in quantity terms Boluda and Noatum terminals are leading by the number of the terminals and different locations, but not in the volume of goods received. All in all, the process of elaboration of the present thesis could be represented in the following figure:

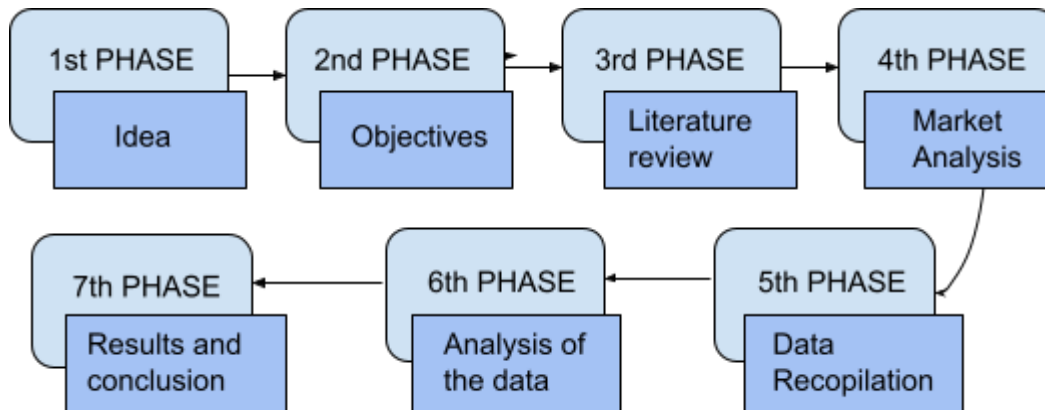


Figure 4.1. Phases. Own Elaboration.

The initial work started with the idea of the present thesis (1st phase), which consequently is followed by the next stages (phases). This idea is specified in an approach that defines the problem to be addressed in terms of objectives (2nd phase). Based on the research problem, a review of the literature was carried out, which identifies the relevant concepts and theories, as well as the findings of previous studies that allow us to know the state of the art of the current problem (Market Penetration of TOS) (3rd Phase). The literature review was then followed by providing an overview of terminal operating companies worldwide and the container terminal in Spain alongside with the existing TOS packages on the market. Once the sample has been established, the data is collected (5th Phase). With the data collected, the analysis is carried out using the analytical techniques defined in the previous section, which allow answering the objectives and evaluating them (6th Phase). Finally, the interpretation of the results is carried out and the subtraction of conclusions proceed, which are the focus of the next final sections (7th Phase).

Chapter 5

Results and discussion

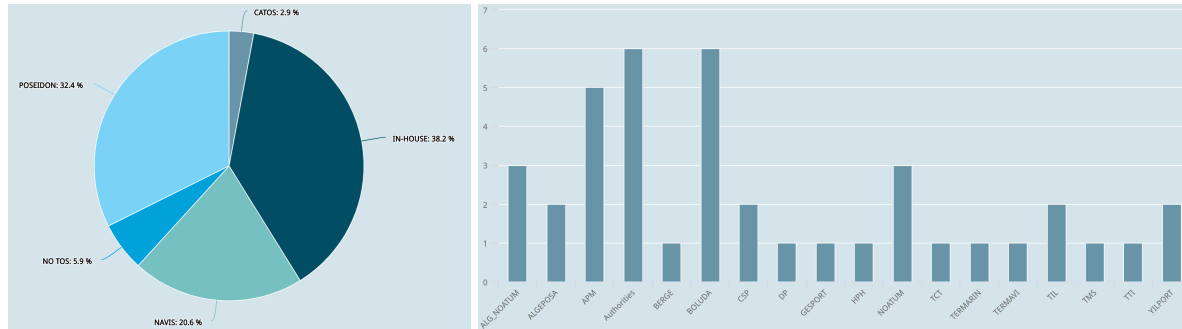


Figure 5.1. TOS distribution. Own Elaboration.

Figure 5.2. Container Operating Company Density in Spain.

Own Elaboration using the library “highcharter” in R software.

It could be seen that Spanish ports are well equipped and have many facilities for better functionality in general. In addition, there is a presence of worldwide container terminal operators companies in the largest ports of Spain such as Barcelona (HPH and APM), Valencia (APM and TIL), Tarragona (DP World) and Algeciras (APM). The well thought locations are determined by strategic interests of those operators, ensuring their presence in the ports with the biggest traffic, especially export of agricultural and textile products, as well as chemicals (e.g. Repsol), vehicles (e.g., Seat) and other goods of different nature. As for TOS we can observe that the most used commercial solution is Navis and Poseidon (TOS elaborated by PACECO España) and it could be justified by the fact that the container operating company with the major presence in Spain (by the number of container terminals) uses the same software in all its locations (APM uses Navis TOS at its top locations while all Boluda terminals use Poseidon). Nevertheless, it is only in the quantity of terminals, but not about their share in terms of container traffic. If we take a closer look at the last statistics reported by *Puertos del Estado* (Figure 5.4, Figure 5.5), we can see that the most volume of goods in containers (in tons) were received by ports where APM Terminals are located (Algeciras, Valencia) and the drastic difference between Boluda’s locations (mostly Canary Islands: Las Palmas and Santa Cruz de Tenerife can be observed in the Figure 5.4). If we turn our attention again to APM terminals locations, we can see that APM has terminals at all top 3 leading terminals in terms of goods’ volume (in tons): Algeciras, Valencia and Barcelona. Algeciras terminal is the leading one and was the first APM terminal with Navis N4 TOS installed. As for Barcelona’s terminal, there is undergoing migration from ARGOS (in-house TOS) to Navis N4 (comercial TOS). Valencia terminal still operates with in-house TOS ARGOS and it is expected to have Navis N4 installed (recently announced in January 2021 as well as CSP Terminal, both started preparations for the NAVIS N4 Implementation). It is noticeable that the most leading terminals in container operations have N4 or other commercial TOS installed (TIL Las Palmas, Boluda, APM Barcelona, Algeciras, CSP, Yilport) with the exception of TTI Algeciras, DP World and HPH Terminals that have their in-house

solutions implemented. There is a certain correlation (Figure 5.2) between the container operating company (variable: "COMPANY") and the implementation of the commercial TOS Solution (variable: "TOS"), especially the leading N4 by NAVIS which is already installed at some terminals in Spain and shortly will be implemented at others (APM Algeciras already installed, Barcelona in process and Valencia to be expected). Yilport Huelva and Ferrol Terminals are already operating with Navis, which provides Yilport with a competitive advantage on the Atlantic coast. In addition, there is a correlation (0.5-0.6) observed between the coast (variable

"ZONE" which represents Mediterranean, Atlantic and Cantabrian coast) where terminals are located and the TOS (variable "TOS") solution they

have installed. Moreover, there is a strong correlation (0.8-0.9) between terminal operating company (variable "COMPANY") and the TOS solution (variable "TOS") installed. This strong correlation must be due to the fact that the leading APM Terminals have the NAVIS TOS installed (Valencia and Barcelona were marked as NAVIS users as they are in a migration process and expected to have it shortly) and all the Boluda Terminals have POSEIDON TOS solution already installed while in-house solutions are used by all Noatum terminals and again, Navis is used at both terminals of a game-changer YILPORT company.

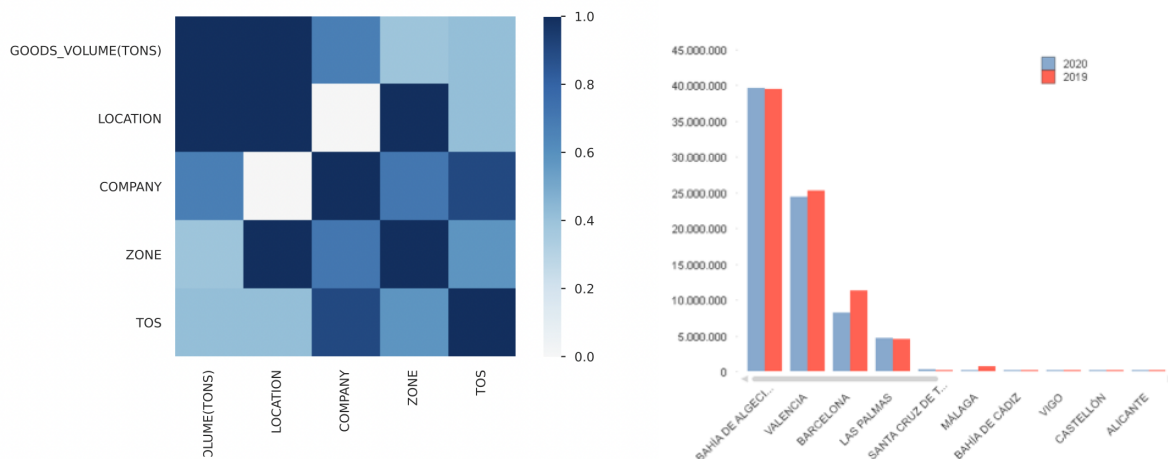


Figure 5.3. Correlation matrix. Own Elaboration using pandas profiling module in Python.

Figure 5.4 Goods in containers in transit (tons). Source: <http://www.puertos.es>

Algeciras where TTI and APM terminals are located receives more goods than all Boluda terminals location receive (according to statistics subtracted from puertos.es). In the following figure we can clearly see that the difference between Boluda Terminals location (marked in red) and APM leading locations (marked in orange) is drastic. Any of APM top locations receives more goods in containers than the sum of all Boluda locations (take into account that it is just an approximation as far as they are statistics of ports and not the terminals but even so, the difference is undeniable).

Autoridad Portuaria	Mes diciembre		Acumulado desde enero		
	2019	2020	2019	2020	Var. (%)
A CORUÑA	0	0	35	17	-51,43
ALICANTE	93 544	88 969	1 237 828	1 078 648	-12,86
ALMERÍA	33 111	39 360	385 694	417 528	8,25
AVILÉS	0	0	2	0	-100,00
BAHÍA DE ALGECIRAS	4 911 254	5 211 819	64 283 309	65 419 527	1,77
BAHÍA DE CÁDIZ	28 650	176 762	367 850	936 024	154,46
BALEARES	27 310	27 565	459 002	346 997	-24,40
BARCELONA	2 555 072	3 479 223	34 182 740	31 966 359	-6,48
BILBAO	509 578	337 206	6 717 568	5 183 130	-22,84
CARTAGENA	60 328	42 977	889 187	703 556	-20,88
CASTELLÓN	188 952	153 504	2 763 036	1 849 936	-33,05
CEUTA	7 416	7 510	114 973	74 777	-34,96
FERROL-SAN CIBRAO	6 282	12 065	95 405	129 224	35,45
GIJÓN	78 955	126 369	1 003 424	1 061 435	5,78
HUELVA	47 502	56 960	589 779	640 754	8,64
LAS PALMAS	899 376	1 042 061	10 984 193	11 441 606	4,16
MÁLAGA	120 201	57 983	1 431 971	616 649	-56,94
MARÍN Y RÍA DE PONTEVEDRA	79 147	54 445	873 911	550 735	-36,98
MELILLA	9 662	4 943	138 351	80 183	-42,04
MOTRIL	57	0	4 988	573	-88,51
PASAIA	0	11 230	0	40 496	
SANTA CRUZ DE TENERIFE	320 098	301 217	3 312 267	3 240 904	-2,15
SANTÁNDER	21 509	39 902	178 637	303 453	69,87
SEVILLA	74 977	75 602	988 769	894 197	-9,56
TARRAGONA	30 332	37 379	454 389	411 058	-9,54
VALENCIA	4 780 658	5 820 428	60 831 738	63 391 454	4,21
VIGO	209 610	234 645	2 659 602	2 780 308	4,54
VILAGARCÍA	26 807	26 837	340 978	312 285	-8,41
Total	15 120 388	17 466 961	195 289 626	193 871 813	-0,73

Figure 5.5 Goods in containers in transit (tons) acumulado. Source: <http://www.puertos.es>

It is also worth mentioning the main Navis's competitor - Tideworks Technology it is not presented at none of the Spanish terminals, highlighting the presence of only one worldwide leading TOS solution- Navis. The other commercial solution that made competition to Navis' N4 are Corean Catos TOS at MSC Terminal Valencia (TIL group) and Spanish Poseidon implemented at various container terminals in Spain (mostly at Canary Islands and as it was previously mentioned, the traffic of containers is not comparable to the volume of the other top locations). In general, it is not clear if terminals prefer in-house or commercial solutions. Currently DP World and HPH terminals rely on their in-house TOS solutions (Zodiac for DP World and nGen for HPH), APM Terminals which still have in-house TOS at some of its locations and quite possibly are pending installation of the NAVIS N4 solution in the foreseen future. Another leading terminal located in Algeciras (TTI Algeciras) is still using in-house TOS.

It is highly proper and unique to each terminal to decide which solution to implement whether it would be a commercial or in-house TOS developed exclusively for their terminal. In-house TOS requires high investment which not every terminal operating company can afford and thus these should study whether it would be profitable or not for the operations that each terminal maintains. The cost questions and the profitability of the investment, its efficiency and other cost related questions are unique for each terminal and requires detailed study which is out of the scope of the present work.

Navis is considered one of the best terminal operating systems worldwide, a part of Cargotec Corporation, it is a provider of operational technologies and services that unlock greater performance and efficiency for the world's leading organizations across the shipping supply chain. In addition, Navis has recently strengthened its position by acquiring other solutions which appeared on the market as Octopi (by Cetus Labs) and Master Terminal (by Jade logistics). All in all, Navis has a tendency to acquire potential competitors thus strengthening its position on the market by offering a range of solutions. It is important to

highlight the competence that Poseidon software has made by providing TOS solutions to all the Boluda

Terminals, Termavi, Concasa, Gesport terminals and other small terminals. Nowadays there is a quite tight competitiveness presented from the global leaders in container operations yet we can observe that many strategically important terminal locations are held by Spanish container operators such as Boluda Shipping, Noatum and Algeposa. In Annex there is a table summary attached with the port's location, terminal operating company and their TOS in use for a better overview.

Chapter 6

Conclusions

We can conclude that in general, there is a high level of market penetration of TOS as well as a good level of automatization in Spanish ports, especially because Spain has a good location which allows to transport goods within Europe and also to Africa and America. High demand on the service and the nature of Spain, demand on its agricultural products and location as a transshipment hub for many shipping operators made it of vital importance to make the terminals highly developed and be constantly updated. There are three leading companies worldwide presented: APM terminals, DP world and HPH in addition to a game-changer Yilport Terminal. The latter has strengthened its position by acquiring 100% of Huelva Terminal in 2018 (previously it was shared with Concasa) on the Atlantic coast in addition to Ferrol terminal which is in the process of expansion. Moreover, it is important to mention that Yilport has 7 terminals in Portugal which provides the company control all over the Atlantic coast of the Iberian peninsula. It is also worth mentioning that Yilport prefers NAVIS TOS for its terminals. Nowadays, NAVIS is the best TOS solution existing on the market and the leading Spanish terminals (in container traffic) choice. Nevertheless, future research would still be necessary to prove whether it would be profitable for the terminals to undergo the investment into a commercial TOS solution, which cost is out of the scope of the present work. In fact, future research that could be done on the field, apart from the investment profitability, would be to investigate on the operations efficiency of the terminals after installing commercial TOS (e.g. NAVIS which would be introduced soon at the APM Terminals of Valencia and Barcelona). All in all, the use of TOS is implemented in most of the ports, demonstrating the demand on Spanish inland and maritime services transportation to other continents and the need to constantly upgrade its services as well as the exponential increase in AI applications for ports. The question is whether or not it is actually profitable for terminals to switch to commercial TOS solutions such as NAVIS N4 from their in-house solutions. In the overview of the TOS packages it was seen that the offer is rich whether it is a software for multipurpose, container or small/medium cargo terminal, so the companies have a wide offer. Hence, there is a need to study cost efficiency and investment profitability for each individual terminal to determine the need of TOS solution change. Businesses already understood the need of digital services, and the pandemic has accelerated them even more as well as the development of new technologies, so it is foreseen that nowadays being up to date is a crucial requirement for a business to survive providing the best solutions to customer's needs, especially features as an automated reports generation, KPIs dashboards, cloud solutions and remote access from every device. The digitalization of the services became a necessity, accelerated by a pandemic and its unexpected circumstances. Additionally, the future places high demands on paperless shipments to facilitate the flow of goods and provide greater, faster and more effective data exchange. The latter is what the modern commercial TOS solutions stand for: easy in use and efficient in operations performance.

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ANNEX

PORT/CITY	CONTAINER TERMINAL (YES/NO)	TERMINAL OPERATING COMPANY	TOS
ALICANTE			PACECO POSEIDON
ALMERIA			
AVILES		 	IN-HOUSE
ALGECIRAS			IN-HOUSE
			NAVIS N4
CADIZ			PACECO POSEIDON
BALEARES			
BARCELONA			NAVIS N4*
			NGEN (IN-HOUSE)
			PACECO POSEIDON
BILBAO			IN-HOUSE
CARTAGENA			IN-HOUSE
CASTELLON			IN-HOUSE
			IN-HOUSE

PORT/CITY	CONTAINER TERMINAL (YES/NO)	TERMINAL OPERATING COMPANY	TOS
CEUTA			
FERROL			NAVIS N4
GIJON			IN-HOUSE
			IN-HOUSE
HUELVA			NAVIS N4
A CORUÑA			IN-HOUSE
LAS PALMAS	 	 	NAVIS N4 PACECO POSEIDON
MALAGA			PACECO POSEIDON
MARIN			N/A
MELILLA			NO TOS INSTALLED*
MOTRIL			NO TOS INSTALLED
PASAJES			N/A
TENERIFE			PACECO POSEIDON

PORT/CITY	CONTAINER TERMINAL (YES/NO)	TERMINAL OPERATING COMPANY	TOS
SANTANDER*			IN-HOUSE
SEVILLA			PACECO POSEIDON
SAGUNTO			IN-HOUSE
TARRAGONA			ZODIAC (IN-HOUSE)
VALENCIA	  	  	NAVIS N4* NAVIS N4** CATOS
VIGO			PACECO POSEIDON
VILLAGARCIA			PACECO POSEIDON

NAVIS N4* - Recently announced migration from in-house TOS ARGOS to NAVIS N4

NAVIS N4* - Recently announced migration from in-house TOS (previously CSP was Noatum Terminal) to NAVIS N4

Santander* - Container Terminal coming soon. Announced in July 2020

