Identifying user requirements of an information system for management container handling procedures

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Abstract
It is widely known that the importance of container transportation is growing in global maritime business. Under this context, the purpose of this study is to identify key container management processes, along with the necessary user requirements of Information Technology (IT) systems that should be used by any terminal's management in order to provide general guidelines for establishing effective container management operations.

Introduction

The introduction of the container in 1960 led to a revolution in global trade as it: (i) optimized space usage in transportation modes (ii) could be handled faster and easier, thus significantly reducing handling times, (iii) reduced incidents of product theft, and damage during transportation, loading and discharge, (iv) reduced paperwork since it was handled as a single transport unit for which one document was required, and (v) reduced insurance costs since the container was insured as a single unit which effectively protected its content (Gargalis and Libadaras, 2013).

As a result, in the forthcoming years after the introduction of the container, trade between global industrialized countries increased by almost 8 times. Large container vessels were then developed, that exploited economies of scale in transportation, thus reducing significantly ship transportation costs. These low transportation costs made the off-shoring of production operations economically viable, thus resulting in the development of extensive globalized shipping networks that connected distant production locations with various demand points around the world. On this basis, seaports have played a vital role as gateways that connected sea and shore. Fully mechanical container terminals were developed for handling these container vessels, time and cost efficiently, while reassuring all security standards during loading, discharge, transportation and storage.

Furthermore, maritime transportation plays an important role in the development of international trade of the European Union as 90% of the international trade volumes and 40% of the internal trade volumes are transported by maritime transport (Eurostat, 2009). Considering today that container ships represent the most dominant transportation mode in globalized supply chain networks, the development of effective container terminals is critical for the reliable and efficient operation of these networks. Under this context, the purpose of this study is to identify key container management processes, along with the necessary user requirements of Information Technology (IT) systems that should be used by any terminal's management in order to provide

general guidelines for establishing effective container management operations.
Improving the efficiency of Container Terminals (CTs) is critical for the development of effective door-to-door supply chain networks. On this basis, the optimization of their operations may have significant value added effects throughout the whole supply chain. As the optimization of CT operations can be mainly achieved through the optimization of container management procedures and the employment of IT systems, the purpose of this paper is to map the: i) Critical container management processes, and ii) Necessary user requirements from the IT systems that should be employed by the port's management, in order to develop general guidelines for the design of effective container management operations.

The paper is organized as follows; in the next section the container management operations are identified and analyzed. Then, a synopsis of the IT systems for the effective of the above management operations is presented. In the fourth section the empirical findings of a research that identified the requirements of the IT system are discussed. The sample consists mainly of employees who are already users of an information system for container handling in four port authorities.

Container handling procedures

This section provides an analysis of the main container management operations associated to the three types of containers:

(i) Conventional cargo containers.
(ii) Empty containers, and
(iii) Hazardous cargo containers.

Conventional Cargo Container Management
The management of conventional cargo containers represents more than 80% of the terminal's total operations and thus, their effective management may significantly improve its overall performance. These operations are classified into the operations associated to their exports and their imports. The operations associated to their exports are the following:

- Physical inspection of the containers' (inspection of their stamp, physical condition etc.) at the terminal's gate.
- Control of the containers' enclosed documents at the terminal's gate.
- Indication to the truck driver, of the containers' discharge position within the terminal's storage area.
- Issuance of the containers' discharge and storage commands and their transmission to the straddle carriers (or to other alternative equipment).
- Determination of the export container ship's berthing location at the terminal's quay.
- Determination of the necessary equipment for the containers' loading operations, along with the number of port workers required.
- Development of a specific container sequence, based on the order that these will be loaded onto the ship (that is based on the Master Bay Plan).

The operations associated to their imports are the following:

- Submission of the ship's import manifest to the Port Authority and the Customs Office.
- Receipt of the import containers by the Officer of the Port Authority after their discharge on the quay and their further inspection in order to identify whether: (i) each container's number is correct, and (ii) its stamp is not infringed. Then, the containers' receipt is electronically recorded.
- In the case of partial cargo loads (groupage), their receipt is conducted by the terminal's warehouse, based on the mailing list supplied by the cargo's agent and after their inspection with respect to their brands, and their quantity stated at the bill of lading.
- After the containers' and the partial cargo are received, an "Execution Report" is formed and passed to the cargo's agent and the Customs Office.
- When the importer's agent carries out customs formalities and receives the delivery order of each container, sealed by the customs office for release, the cargo is delivered to the Port Authority.
- The importer then pays the General Port and Warehouse Rights, and an invoice is issued by the Port Authority.
- The importer is informed about the state of receipt of its cargo by the Port Authority.
- The cargo is delivered by the Port Authority in the terminal's storage/stacking area and the Port Authority's Information System is simultaneously updated.
- The Port Authority publishes the Bulletin of receipt, which is signed by the recipient, stating that he accepts the receipt.
- The cargo delivery is completed and its bill of lading is removed from the system.
- The imported goods that are not collected by the importers within 45 days, are transferred to the Public Warehouse, unless the importer requests and receives, by the Customs Office, an approval for extending the cargo's residence time in the Port Authority's warehouse.

Empty Container Management Procedures

According to Liapis, (2006), every region has a central CT and a number of smaller regional ones. The management of each regional terminal informs the central one about the stock levels of its empty containers. Then, the central CT collects this information from all the regional terminals and schedules the deliveries of the empty containers between the terminals in such a way that the region's total transportation costs are minimized. To this end, the central CT additionally provides instructions to the regional terminals regarding the number of the empty containers movements required for meeting the importers and exporters needs for empty containers throughout the whole region.

The required procedures associated to the export of empty containers are the following:

- The empty export containers arrive to the terminal's gate by trucks from the importer.
- The importer's agent sends an Electronic Data Interchange (EDI) message to the terminal's management that indicates the number of empty containers delivered, and at the same time he issues container

zone permits that will accompany the empty containers in order to pass the customs control.
- Then, the empty containers are stored in the Terminal's empty container slots until loading on the ship.

The required procedures associated to the import of empty containers are the following:

- The exporter sends trucks to collect the empty imported containers. The exporter's agent sends an EDI message to the Port's management indicating the number of empty containers he intends to receive. At the same time, he issues exit permits that will accompany the empty containers during the customs control.
- After the approval of the empty containers release, the exporter pays the empty container's storage costs to the Port Authority.

Hazardous Cargo Container Management
Hazardous cargo can be classified to the following categories:

- Petroleum in accordance with Annex I of the International Convention Marpol 73/78.
- Gases as defined in GC Code.
- Noxious liquid substances/chemicals, including waste, as defined in the BCH Code and Annex II of the International Convention MARPOL 73/78.
- Solid bulk cargoes which exhibit chemical risk in accordance to the BC Code.
- Harmful substances in packaging covered by Annex III of the International Convention MARPOL 73/78, and
- Packed hazardous goods: substances, materials and articles as defined in the IMDG Code.

The packaging and transport unit (i.e. containers) of hazardous cargo should carry warning labels, depending on the category of the cargo's risk, in order to communicate the potential dangers throughout all stages of the supply chain and thus handled accordingly. The empty un-cleaned packages should be also treated as hazardous cargoes, sufficiently purged by residues of their dangerous cargo and evacuated from hazardous vapors.

The following table classifies the container terminal operations based on the organizational levels:

Table 1: Classification of container terminal operations (Source: Vlachos et al., 2010)

	Container Terminal (CT) Functions/Decisions	**Strategic**	**Tactical**	**Operational**
Strategic Design & Management	Spatial Planning of the Container Terminal	√		
	Number of Berth Selection	√		
	Transportation Equipment Selection (Type & Number)	√		
	Gantry Crane Type Selection	√		
	Stowage Equipment Selection	√		
	Stowage Policies / Rules	√		

	Principles of CT Operations (Pre-Announcements, Time-Windows)	√		
	Contracts –Billing Policies - Discounts – Criminal Clauses	√		
	Manpower Allocation – Wages	√		
	Equipment Maintenance - Availability	√		
	Management of Spare Part Warehouses – Availability	√	√	
	Administrative Policies for Document Circulation	√		
Operations on Ships	Distribution of Berths to Arriving Ships	√		
	Gantry Crane Scheduling		√	√
	Resource Allocation - Cranes		√	√
	Manpower Allocation - Homochiral		√	√
	Development of a Loading Sequence - Loading Plan		√	√
	Re-Stowage Through the Quay		√	√
	Relocations within Ships		√	√
	Development of Container Transportation Sequences to the Quay			√
Transportation Operations To the Quay	Resource Allocation - Transportation Equipment		√	√
	Routing of Transportation Equipment to the Quay			√
	Development of a Sequence for Transportation Equipment			√
Operations of the CT's Yard	Discharge Of Full Containers			√
	Scheduling of Discharge/ Distribution of the Discharge Area		√	
	Discharge of Empty Containers		√	√
	Discharge of Transshipment Containers		√	√
	Discharge of Reefer Containers		√	√
	Discharge of Hazardous Cargo Containers		√	√
	Development of a Container Transportation Sequence			√
Container Receipt and Deliver	Resource Allocation - Transportation Equipment- Delivery			√
	Routing of Transportation Equipment – Delivery			√

	Gate Operations (Number of Input and Output Gates)			√

IT Systems for effective container management

Nowadays, the role of container ports is considered to be more significant than ever before, as they are challenged to handle mega vessels with a capacity of 15,000 TEU and beyond. Therefore, they are forced to increase their productivity, cost-efficiency and effectiveness, so as to attract the big market players.

The decision making process at a container terminal can be realized at a strategic, tactical and operational level. At the strategic level, issues to be taken into account refer to the terminal layout, the material handling equipment and the operations pattern that could be used, the number of berths available at the quay etc. At the tactical level, the type of information exchanged has to be determined, e.g. the policy of container storage.

At the operational level, the daily operations must be taken into consideration, e.g. the storage area of a specific container, the berth that should be allocated to a calling vessel, the way that containers will be stowed etc (Vis and Koster, 2003). Wickert et al (2012) highlighted that the major strategic objective of a container terminal should be the development of innovative business concepts, through the provision of value added services, in order to increase the rate of settlement of new companies.

Furthermore, at the operational level, they identified objectives such as the:

- Optimization of in-and outbound processes at the transshipment terminal to enhance transparency.
- Implementation of ICT tools to handle promptly last minute notifications from customers.
- Optimization of pre-and post-haulage time required for the transshipment, and the loading / unloading of containers, and
- More accurate planning of terminal resources, based on specific customer orders.

The achievement of these objectives leads to considerable time reduction that vessels and external trucks spend in the port and thus, contributes to increased productivity (Lau and Zhao, 2008; Yu and Oi, 2013) for all stakeholders (port users), namely shippers, shipping lines, forwarding companies (Yuen et al, 2012). Besides, the achievement of the above mentioned objectives can be facilitated by the use of port Information Systems (IS) that enable electronic information availability and accessibility (Yuen et al, 2012).

Information speed supports the prompt cargo movement throughout the entire supply chain. Apart from the stakeholders' involvement at an early stage; technical support and training are important. Reliable IT infrastructure, the development of human resource skills, the identification of hardware and software suppliers are highly valued (Bagchi and Paik, 2001).

Additionally, existing processes can be assisted by powerful information technology (IT) and logistics control software systems (Günther and Kim 2006).

Indicative challenges for the stakeholders along with the implemented solutions through incorporation of IS and IT into the terminal operations are presented in the next table:

Table 2: Challenges and implemented solutions into the terminal operations

Challenges	**Solution**	**Authors**
Port connectivity with hinterland	Computerized container control system increases the operating efficiency of the terminal.	Kia et al (2000)
Time spent by vessels in ports	Application of computerized tele-transmission of manifest and stowage plan details from the port of loading to the port of discharge.	Kia et al (2000)
Prompt flow of information	Use of electronic devices (e.g. Microwave technology, Tagging technology, Barcode scanner, Radio frequency microcircuit system, Voice recognition technology)	Kia et al (2000)
Terminal planning, vehicle scheduling, loading, route optimization, network design	Real-time, dynamic DSS	Harris et al (2015)
Response to unforeseen events (integration with the supply chain)	Agent-based container terminal event management system	Bearzotti et al (2013)
Online optimization	Optimization-based DSS	Stahlbock and Voß (2008)
Networking issues, documentation of slot allocation, transparency and truckers' time spent	(a) Digital interface for digital incoming data to increase the predictive process optimization. (b) Container slot visualization along with predictive messages to achieve optimized storage. (c) Interface with marshalling yards to reduce internal distances. (d) Pre-notification	Wickert et al (2012)

	message system to reduce the drivers' waiting time.	

The evolution of major ports, such as Singapore and Hong Kong is not only based on their strategic location, but rather on the establishment of Information Systems and Technologies.

According to Murty et al (2005), the Port of Hong Kong has adopted a DSS that operates on the basis of intelligent decision support models and algorithms, supported by an efficient infrastructure that can handle unforeseen events and uncertainties in distribution of workload, due to weather, road traffic conditions, etc. The daily real time decisions that have to be made refer to:

- Allocation of berths to arriving vessels
- Allocation of QCs to docked vessels
- Appointment times to external trucks
- Routing of trucks
- Dispatch policy at the TG and the dock
- Storage space assignment
- RTGC deployment
- IT allocation to Quay Cranes
- Optimal internal truck hiring plans

According to Lee-Partridge et al (2000), the Port of Singapore Authorities (PSA) agreed that the terminal operations have to be supported by fast and accurate information flow between the port and the stakeholders. Therefore, PSA has invested hundreds of millions of dollars in IT to support administrative, operational and planning activities.

The most prevalent systems developed by the PSA include the following:

- CITOS: assists in planning and directing all container handling operations in real-time.
- BOXNET: an electronic data interchange (EDI) with hauliers to facilitate reorganization of their operations and enhance their fleet utilization.
- PORTNET: an EDI system that provides port users with a 24/7 electronic information and communication link with PSA. Users can also upload their work orders online. It is considered a one-stop solution to users, as it allows connection with the TRADENET that supports customs clearance.
- FastConnect: enables intra- and inter-terminal connections for transshipment of containers.

Effective container management procedures require the installation of Integrated Information Systems, in order to diffuse the necessary information between the terminal's staff. The most critical IT systems, as presented by Sxoinakis and Koukouloudi, (2004), are the following:

- Centralized Information Management System: This system supports the dynamic movement of data and information between the terminal's

subsystems. The purpose is the collection and distribution of data between different sources.

- Official Document Filling System: This system supports the downloading process of the necessary documents for the delivery and receipt operations of containers.
- Administrative work system: This system supports the issuance of exit, loading and transit permits, the maintenance of records and the submission of customs clearance documents.
- Pricing system: This system supports the estimation, publication and management of invoices, with respect to the terminal's storage and loading/discharge rates.
- Entry/exit control system: This system supports the automatic control of containers and its vehicle using a smart card and by automatically releasing the gate after a successful cross-check of the vehicle's necessary documentation.
- Control of loading/discharging: This system supports the management of loading/discharge operations through the employment of wireless terminals, and by electronically monitoring the loading and discharge movements performed.
- Geographical information system: This system supports the graphical representation of container's movements within the terminal in real time.
- Inventory system: This system supports the electronic confirmation of the position of the container in the terminal's stowage area.
- Stowage planning system: This system supports the distribution of container's in the stowage area.
- Equipment Management System: This system supports, via wireless terminals, the stowage plan system, while passing the necessary instructions to the straddle carriers for container movements.

Empirical findings

This section presents and analyses the results of the descriptive analysis of the questionnaire regarding the web platform requirements for the management of containers' handling operations.

The questionnaire includes mainly closed type questions and consists of 3 parts:

- The Part A includes questions about the profile of the respondent (including his/her name, the name of the organisation, his/her position, roles and responsibilities, and if these are related with container handling. Finally if he/she is using any Information System for container handling).
- The Part B was answered in case of the "Yes" answer in the previous question. It asks the name of the Information System, the functionalities of the Information System that you are using and how often does he/she use this Information System. Finally, how satisfied he/she was about the Information System.
- The Part C asks the significance of various functionalities of the information system for container handling.

The questionnaire and some frequency tables are presented in the Appendix. The sample includes 210 employees in the following port authorities: Port of Varna, Port of Odessa, Port of Thessaloniki, Port of Alexandroupolis and the Port of Hamburg.

Parts A and B

The sample consists mainly of employees who are already users of an information system for container handling (92 percent). The systems are either custom-made (Port of Varna or Port of Odessa) or commercial packages (Port of Thessaloniki, Port of Alexandroupolis and Port of Hamburg). They are using the system for the management of the containers information, and for the maintaining of information regarding their movements inside the port. The majority (almost 90%) uses it on a daily basis. The following table presents their satisfaction according to specific factors:

Table 3: Satisfaction according to specific factors

	Don't know	Not satisfied	Satisfied	Very satisfied
Regarding data entry and usability	6	0	96	108
Regarding the support of the container handling processes	6	0	66	138
Regarding the support of decision making	6	0	85	120

According to the findings the users of the systems are satisfied (more than 60%) which proves the significance and appropriateness of the existed information system.

Part C

The following summarized table identifies the significance of the web functionalities.

Table 4: Significance of the web functionalities

	Don't know	Not significant	Significant	Very significant
Electronically monitoring of the loading and discharge movements performed	0	0	48	162
Real time information about the location of the container	0	0	48	162
Real time information about the state of the container (security, humidity, temperature)	0	42	60	108
Graphical representation of container's position within the terminal in real time	0	0	60	150
Graphical representation of container's movements within the terminal in real time	0	6	78	126

Electronic management of customs clearance documents	6	12	66	126
Passing the necessary instructions for container movements	0	0	96	114
Automatic control and cross-checking of the container's movement	0	18	48	144
Electronic confirmation of the position of the container in the terminal's storage area	6	18	30	156
Log (history) files that maintains the above information	0	0	66	144
Provision of reports and documentation	6	0	42	162
Downloading of the documents for the delivery and receipt operations of containers	0	18	78	114

The results show that all the above functionalities are significant for an effective and efficient handling of containers in a port terminal. This will give a useful input for the design and the implementation of the web platform which is the main deliverable of the SETRACON project.

Conclusions

Considering that container ships represent the most dominant transportation mode in globalized supply chain networks, the development of effective container terminals is critical for the reliable and efficient operation of these networks. Under this context, the purpose of this report is to identify key container management processes, along with the necessary IT requirements systems that should be used by any terminal's management in order to provide general guidelines for establishing effective and sustainable container management operations.

Hence, the strategic design and management functions, the operations on ships, the transportation operations to the quay, the operations of the CT's yard and the container receipt and delivery operations have to be thoroughly supported by up-to-date and real time Information Technology, so that the operations are executed smoothly. The research revealed that web functionalities that support the monitoring of loading/ discharging operations, the exact location of the container in the port and storage area, along with a graphical representation of its movement and state, the electronic management of the customs process, the dissemination of instructions for the respective container movements, together with automatic control and cross-checking, the provision and ability to download reports and related documentation, as well as the maintenance of history files, represent

critical features, on behalf of the port users, of a web platform that would assist their strategic, tactical and operational processes.

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Appendices

Questionnaire

Part A: Profile of the respondent

Name: …….
Organisation name: ……
Position: ……
Roles and responsibilities: ……
Are your responsibilities related with container handling? (Yes / No): ……
Are you using any Information System for container handling? (Yes / No): …….

If you answered No in the previous question please skip Part B and go to Part C

Part B: Use of Information System for Container Handling

Please name the Information System.
……

Please name the functionalities of the Information System that you are using.
……

How often do you use this Information System?
1) Daily [ ]
2) Weekly [ ]
3) Rarely [ ]
4) Whenever it needs [ ]

How satisfied are you about the Information System?

	Don't know	Not satisfied	Satisfied	Very satisfied
Regarding data entry and usability				
Regarding the support of the container handling processes				
Regarding the support of decision making				

Please identify which other functionalities could be provided by the Information System.
……
……

Part C: Needs of an Information System

How significant are the next functionalities of an Information System for Container Handling?

	Don't know	Not significant	Significant	Very significant

Electronically monitoring of the loading and discharge movements performed				
Real time information about the location of the container				
Real time information about the state of the container (security, humidity, temperature)				
Graphical representation of container's position within the terminal in real time				
Graphical representation of container's movements within the terminal in real time				
Electronic management of customs clearance documents				
Passing the necessary instructions for container movements				
Automatic control and cross-checking of the container's movement				
Electronic confirmation of the position of the container in the terminal's storage area				
Log (history) files that maintains the above information				
Provision of reports and documentation				
Downloading of the documents for the delivery and receipt operations of containers				

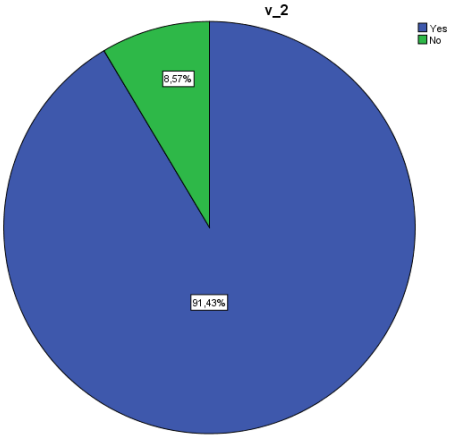
Frequency tables

v_1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	70	100,0	100,0	100,0

v_2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	64	91,4	91,4	91,4
	No	6	8,6	8,6	100,0
	Total	70	100,0	100,0	



v_3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Daily	62	88,6	88,6	88,6
	Weekly	2	2,9	2,9	91,4
	Whenever it needs	6	8,6	8,6	100,0
	Total	70	100,0	100,0