Mr. sc. Edvard Tijan / M. Sc.
Adrijana Agatić, univ. bacc. ing., student
Sveučilište u Rijeci / University of Rijeka
Pomorski fakultet u Rijeci /
Faculty of Maritime Studies Rijeka
Studentska 2
51000 Rijeka
Hrvatska / Croatia
Dr. sc. Bojan Hlača / Ph. D.
Lučka uprava Rijeka / Rijeka Port Authority
Riva 1
51000 Rijeka
Hrvatska / Croatia

Pregledni članak/
Review article

UDK / UDC: 621.869.8:004
65.012.34:004

Primljeno / Recived:
10. travnja 2010. / 10th April 2010
Odobreno / Accepted:
15. svibnja 2010. / 15th May 2010

EVOLUCIJA INFORMACIJSKO-KOMUNIKACIJSKIH TEHNOLOGIJA NA KONTEJNERSKIM TERMINALIMA

ICT EVOLUTION IN CONTAINER TERMINALS

SAŽETAK

Informacijske i komunikacijske tehnologije (ICT) osnova su za implementaciju suvremenih logističkih procesa na kontejnerskim terminalima. ICT-e posjeduju veliki potencijal za korištenje u različitim aktivnostima kontejnerskih terminala. Jedna od najvažnijih uloga informacijsko-komunikacijskih tehnologija je mogućnost povezivanja kontejnerskih terminala s drugim subjektima u lučkoj zajednici, stvarajući na taj način elektroničku zajednicu lučkog sustava (Port Community System). Različiti aspekti informacijsko-komunikacijskih tehnologija na kontejnerskim terminalima čine ih jednim od ključnih resursa i poželjnom investicijom, bez kojih je gotovo nemoguće postići napredak i cilj u pružanju pravovremene i kvalitetne usluge te zadovoljiti potrebe korisnika.

U radu se istražuje uloga informacijsko-komunikacijskih tehnologija na kontejnerskim terminalima kao i vrste informacijsko-komunikacijskih sustava s naglaskom na sustave za planiranje prekrcajnih aktivnosti, te se daje osvrt na virtualnu logistiku kao poseban spoj logistike i informacijsko-komunikacijskih tehnologija na kontejnerskim terminalima.

Ključne riječi: *kontejnerski terminali, informacijsko-komunikacijski sustavi, virtualna logistika*

SUMMARY

Information and communication technologies (ICT) are the basis for the implementation of modern logistics processes in container terminals. ICT possess a large potential for the use in various activities in container terminals. One of the most important roles of ICT is the ability to connect container terminals with other subjects in the port community, creating the Port Community System. Many different aspects of ICT application in container terminals makes ICT one of the key resources and a desirable investment, without which it is virtually impossible to progress and achieve the goal to provide timely and quality services and to satisfy the customer's needs.

This paper aims at researching the role of ICT in container terminals and the types of ICT systems with the emphasis on the planning system for transhipment activities, as well as at giving an overview of virtual logistics as a special blend of logistics and ICT in container terminals.

Key words: *container terminals, ICT systems, virtual logistics*

1. UVOD

Kontejnerski promet, a sukladno tome i kontejnerski terminali kao glavni elementi kontejnerskog prometa bilježe kontinuiran rast i zauzimaju značajan udio u svjetskoj pomorskoj trgovini. Glavni razlog tome je prikladnost kontejnera kao sredstva prijenosa tereta na brz, siguran i ekonomičan način.

Nezaustavljivi tehničko-tehnološki napredak prije svega u veličini brodova, utjecao je na povećanje kapaciteta i uvođenje brzih promjena na kontejnerskim terminalima. Nadalje, evolucija logistike i primjena informacijsko-komunikacijskih tehnologija također su snažno djelovali na osuvremenjivanje kontejnerskih terminala. Danas su informacijsko-komunikacijske tehnologije jedan od najvažnijih elemenata na kontejnerskim terminalima, a njihov cilj je planiranje svih aktivnosti i učinkovito povezivanje svih subjekata lučkog sustava. Uvođenje informacijsko-komunikacijskih tehnologija dovelo je do pojednostavljenja aktivnosti i smanjenja udjela ljudskih resursa u radu kontejnerskih terminala. Značajan i kontinuiran napredak informacijsko-komunikacijskih tehnologija omogućuje planiranje i izgradnju kontejnerskih terminala, planiranje potrebnih prekrcajnih sredstava, planiranje optimalne veličine manipulativnih površina čime se sprječavaju neprofitna ulaganja.

Iako su troškovi uvođenja informacijsko-komunikacijskih sustava veliki, potrebno je osigurati sredstva jer jedino na taj način kontejnerski terminali svoje usluge mogu pružati učinkovito i time u potpunosti zadovoljiti potrebe korisnika.

2. KONTEJNERSKI TERMINALI

Kontejnerski promet započeo je kada je prijevozni poduzetnik Malcom McLean izumio metalni kontejner, čime je omogućeno okrupnjavanje tereta i zamjena do tada korištenih metoda transporta, što je uzrokovalo pravu revoluciju u pomorskom prijevozu. Malcom McLean nakon toga osniva kontejnersku tvrtku *SeaLand* koja je danas dio najvećeg kontejnerskog brodara *Maersk*. Kontejnerski promet i kontejnerske terminale obilježio je brz i kontinuiran razvoj. Kontejnerizacija je kao siguran, jeftin i brz način transporta napravila prekretnicu u prekomorskom prijevozu i trgovini. Postoje različite definicije kontejnerskih terminala, od kojih se izdvajaju sljedeće: Kontejnerski terminali kao

1. INTRODUCTION

Container traffic, with container terminals as the main element, is continuously increasing and has become an important part of the world merchandise trade. The main reason is the convenience of containers: the means of transferring cargo in a quick, safe and inexpensive way.

Unstoppable technical and technological progress, especially in the size of ships, forced the container terminals to react quickly: to introduce changes to their business processes and to increase capacities. The evolution of logistics has strongly influenced further changes in container terminals as has the introduction of ICT. Today, ICT is one of the most important elements in container terminals, with the goal of planning all activities and the effective linking of all subjects in the Port Community. The introduction of ICT led to the simplification of all activities and to the reduction of human resources in the everyday operation in container terminals. Significant and continuous improvement of ICT provided new possibilities in the planning and construction of container terminals, planning the necessary equipment, planning the optimal size of the surface so that non-profitable investments can be prevented.

While the initial cost of introducing advanced ICT systems in container terminals is large, it is necessary to raise the needed funds because the introduction of such systems ensures that container terminals can efficiently provide the services needed and can meet increased customer's needs.

2. CONTAINER TERMINALS

Container traffic started when Malcom McLean developed the metal container for shipping, which replaced the traditional bulk method of transporting dry goods and revolutionized the transport of goods and cargo. He later founded a container company called "Sea-Land", which is today known as a part of Maersk. Since the beginning, container traffic and container terminals have experienced fast and constant development. Containerisation made a breakthrough in overseas transport and trade, because it is the faster, easier, safer and cheaper way of handling cargo. There are various definitions of container terminals, among which are the following ones: "Container terminals of

element pomorskog prometa nalaze se u morskim lukama, u kojima može biti više od jednog terminala. Glavna svrha kontejnerskih terminala je opslužiti kontejnerske brodove [7, str. 8.]. Kontejnerski terminali prvenstveno služe kao sučelje između različitih načina prijevoza, npr. domaći željeznički ili kamionski prijevoz s pomorskim prijevozom [5, str. 3.].

U samim počecima kontejnerski terminali nisu bili veliki, a oprema, uređaji i postrojenja nisu bili toliko brojni, no s vremenom je došlo da značajnih tehnoloških promjena koje su rezultirale i promjenama na kontejnerskim terminalima. Prije svega to je porast veličine kontejnerskih brodova koji su zbog većeg gaza i većih prijevoznih mogućnosti doveli do potrebe za rekonstrukcijom terminala i tehničkom te tehnološkom modernizacijom. Razvojem tržišta došlo je do evolucije logistike koja danas ima ključnu ulogu u poslovanju kontejnerskih terminala. Transport robe mora se zasnivati na principu [3, str. 216.]: "U pravo vrijeme, na pravom mjestu, uz minimalne troškove kako bi se ostvarila željena razina i kvaliteta usluge." Da bi uspješno odgovorili na promjene i zahtjeve koje je nametnuo porast veličine brodova i moderna logistika, kontejnerski terminali morali su proširiti i nadograditi postojeću infrastrukturu, povećati površine, opremiti se prekrcajnim sredstvima većih kapaciteta i automatiziranim sustavima, izgraditi dobre kopnene osobito željezničke veze, te sve povezati učinkovitim informacijskim sustavom kao najvažnijom karikom. Primjer modernog i logistički orijentiranog kontejnerskog terminala je Euromax kontejnerski terminal u luci Rotterdam koji je postao standard za suvremene kontejnerske terminale.

3. VAŽNOST PRIMJENE INFORMACIJSKO-KOMUNIKACIJSKIH TEHNOLOGIJA NA KONTEJNERSKIM TERMINALIMA

U suvremenim uvjetima poslovanja kontejnerskih terminala nemoguće je na efikasan način organizirati aktivnosti i procese bez učinkovitih informacijskih tehnologija koje moraju omogućiti planiranje, organiziranje, koordiniranje i kontroliranje svih aktivnosti i povezivanje subjekata lučkog sustava. Zajednica subjekata lučkog sustava (Port Community System) predstavlja subjekte lučkog sustava povezane infor-

the maritime traffic network are located in seaports, where more than one terminal can be located in a port. The main purpose of seaport container terminals is to serve container vessels" [7, p. 8]. "Container terminals primarily serve as an interface between different modes of transportation, e.g. domestic rail or truck transportation and deep sea maritime transport" [5, p. 3].

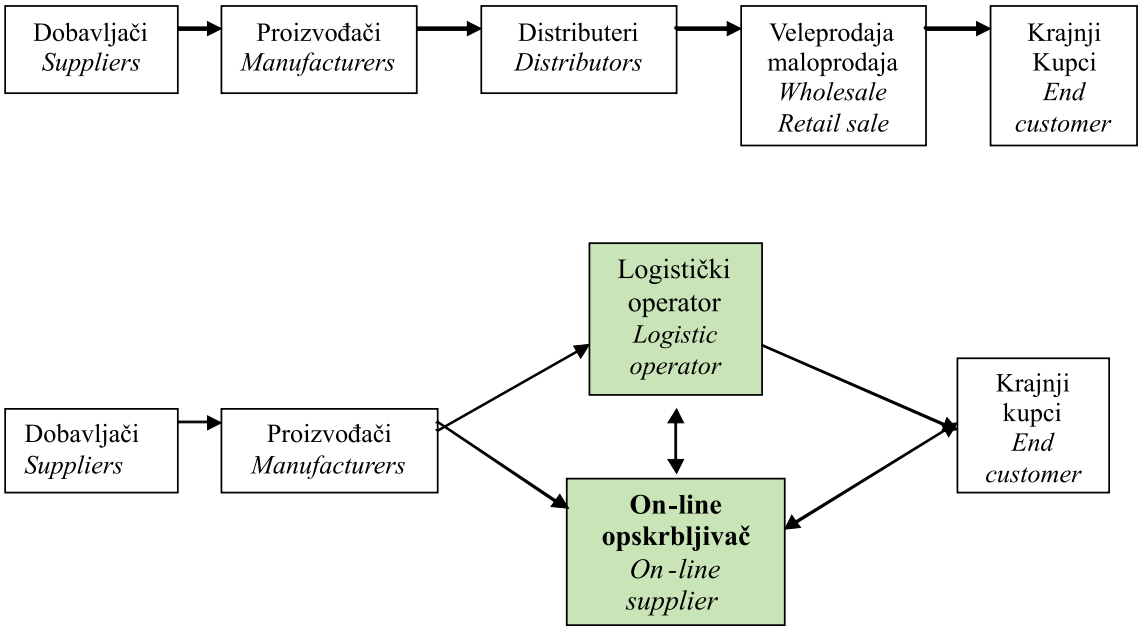
At the beginning, container terminals were not so large and the equipment was not so numerous, but some changes caused a significant increase in terminal size and equipment, primarily the increased size of container ships with larger draft and the ability to transport more containers. Changes in the market and business led to the evolution of logistics. Goods must be delivered based on this principle [3, p. 216]: get the right goods at the right place at the right time to maintain a desired service. To respond to the increased ship size and logistic requirements, container terminals had to expand their infrastructure, by increasing terminal surface, investing in cranes with larger capacities and automation, building railway connections and by investing in efficient information systems. A good example of a well sized, equipped and modern logistic container terminal is the Euromax Container Terminal in the Port of Rotterdam, which became a standard for modern container terminals.

3. THE IMPORTANCE OF ICT IN CONTAINER TERMINALS

It is virtually impossible to organize business processes in container terminals without an efficient ICT system, which should be capable of planning, organizing, coordinating and controlling various operations within container terminals and also within the associated subjects which comprise the Port Community System. "Port Community Systems are holistic, geographically bound information hubs in global supply chains that primarily serve the interests of a heterogeneous collective of port related companies" [13, p. 243]. Logistic processes are strongly connected with ICT systems. (Figure 1)

Figure1 shows the changes in logistic chains for the 21st century. The main change is the reduced number of supply chain subjects that is achieved by substituting them with on-line sup-

Shema 1. Struktura tradicionalnog logističkog lanca i logističkog lanca za 21. stoljeće [12, str. 293.]
Figure 1. *Structure of a traditional logistic chain and a logistic chain for 21st century* [12, p. 293]



macijsko–komunikacijskim tehnologijama [13, str. 243.]. Logistički procesi u snažnoj su sinergiji s informacijskim tehnologijama (Shema 1).

Shema 1. prikazuje promjene u logističkom lancu za 21. stoljeće. Reduciran je broj subjekata u dobavnom lancu koji su zamijenjeni on-line dobavljačem i logističkim operatorom koji imaju zadatak smanjenja troškova i pružanja pune (full-service) usluge krajnjem korisniku [12, str. 293.].

Kontinuirano nastojanje da se smanje troškovi, poveća konkurentnost i ostvari približavanje korisnicima zadovoljavajući sve njihove zahtjeve čine informacijsko-komunikacijske sustave neophodnim za poslovanje kontejnerskih terminala.

Informacijsko-komunikacijski sustavi na kontejnerskim terminalima počeli su se razvijati 70-ih godina prošlog stoljeća kada se tzv. "T-kartica" zamijenila s računalom za planiranje prekrcajnih aktivnosti na kontejnerskim terminalima [6, str. 2.]. Taj sustav nazvan je TOS –Terminal Operating System i kao takav zadržao se do danas u nekoliko varijanti, ovisno o stupnju razvijenosti, no uvijek predstavlja integrirani pristup.

Efikasne i pouzdane lučke logističke usluge uvelike ovise o informacijsko-komunikacijskom sustavu koji može stvoriti značajne uštede u

plier and logistic operator whose role is to reduce costs and provide full service to the end customer [12, p. 293]. Constantly striving to reduce costs, to increase competitiveness and to get closer to the customers makes the ICT systems a basic part of the container terminal business.

ICT systems in container terminals started to develop in 1970's, by substituting paper "T-cards" for planning operations with computer planning [6, p. 2]. The computer system was named TOS (Terminal Operating System). Such a term still exists today, in several different varieties, as an integrated approach.

An efficient and reliable port logistic service is largely dependent on ICT systems. By reducing costs throughout the port supply chain, the usage of ICT can create significant savings. If just the costs of paper administration or telephone usage are considered, the role of ICT in reducing costs is obvious. All parties involved in the container cargo consignment must have prompt and accurate information. Their access to information must be fast and secure. ICT systems are the supporting base to the "just in time" concept as the most active business concept in container terminals.

lučkom logističkom lancu. Ako se razmatraju samo troškovi "papirne administracije" ili uporabe telefona, uloga informacijsko-komunikacijskih sustava u smanjenju troškova postaje jasna. Svi subjekti koji sudjeluju u dopremi/otpremi jedne pošiljke/kontejnera, a osobito krajnji korisnik moraju u svakom trenutku raspolagati točnim podacima. Pristup informacijama mora biti brz i siguran. Informacijsko-komunikacijski sustav potpora je "just in time konceptu" kao najvažnijem načinu poslovanja kontejnerskih terminala.

4. POSTOJEĆI INFORMACIJSKO--KOMUNIKACIJSKI SUSTAVI NA KONTEJNERSKIM TERMINALIMA

Postoji više informacijsko-komunikacijskih sustava na kontejnerskim terminalima. Razlikuju se po softverskim rješenjima pojedinih proizvođača no svi imaju istu svrhu. Najvažniji zadatak informacijsko-komunikacijskih sustava na kontejnerskim terminalima je planiranje prekrcajnih aktivnosti.

Operator kontejnerskog terminala kao osoba zadužena za planiranje, koordiniranje i kontrolu svih aktivnosti na kontejnerskom terminalu u svom radu koristi nekoliko sustava od kojih je najvažniji TOS-Terminal Operating System – sustav za prekrcajne aktivnosti. Slika 1. pokazuje "računalnu mapu", tj. računalne sustave koje koristi terminalni operator. Sustavi su podijeljeni u grupe [6, str. 2.]:

- *Terminal Operating System* (TOS) – sustav za direktno planiranje prekrcajnih operacija na terminalu. Funkcije TOS sustava su praćenje:
  - statusa kontejnera: veličina, težina, tip, posebna uputstva, sadržaj kontejnera
  - resursa: slobodne operativne površine i površine za slaganje kontejnera, lokacija opreme
  - ograničenja: karakteristike operativne površine, potrebna oprema
  - procesa: optimalno slaganje kontejnera, prirориteti u prekrcaju.
- *Gate System* – sustav kontrole i identifikacije kontejnera, propisi za kontejnere, sigurnosne mjere.
- *Community System* – sustav za povezivanje lučkih subjekata razmjenom informacija i elektroničkih poruka.

4. CURRENT ICT SYSTEMS IN CONTAINER TERMINALS

Various ICT systems exist in modern container terminals today. The difference between them is derived from different manufacturers, but the purpose is the same. The most important ICT system in container terminals is the one used for planning cargo processes. The terminal operator, as a person in charge of planning all operations in a container terminal, uses many ICT systems, the most important of them being the TOS (Terminal Operating System), system for direct processing of cargo. Figure 2 shows the "computer map" of a terminal operator. ICT systems are divided into the following groups [6, p. 4]:

- *Terminal Operating System:* All operations in container terminals are planned by the TOS. The functions of TOS are:

– Container status - size, type, weight, onward instructions and cargo type.

– Resources – available yard slots, equipment locations and workloads.

– Constraints - segregation rules, yard layout, traffic management and equipment characteristics.

– Procedures - optimum and maximum stacking heights, container pile rules and traffic priorities.

- *Gate System:* includes all procedures due to a secure identification and throughput of containers on terminals such as weight scales, truck detection, X-ray scans, barriers, Biocard System, LPR Readers etc.
- *Community Systems:* the systems used for connecting the port subjects by exchanging information and electronic messages.
- *Corporate Systems:* system for business functions, tracking and analysing the human resources, creation of financial reports, indication of activities of core business functions etc.
- *Engineering System*: works on diagnostics of equipment and as asset management for all kinds of equipment (to harmonize different financial interests).
- *Ancillary System*: additional system for handling the empty depot and managing the container freight stations.

- *Corporate System* (sustav za poslovne funkcije) – analizira ljudske resurse, izrađuje financijska i računovodstvena izvješća za menadžere.
- *Engineering* – sustav za razvijanje i praćenje tehnoloških inovacija na prekrcajnim sredstvima, dijagnosticiranje kvarova.
- *Anciliary System* – pomoćni sustav za upravljanje praznim odlagalištima i postajama za popravak kontejnera.
- *OCR Handling* – sustav manupilacije i praćenja kontejnera temeljen na Optical Character Reading – optičkom sustavu čitanja tagova u svrhu pripreme kontejnera za prekrcaj.
- *Equipment control* (sustav za kontrolu opreme) – prati rad opreme na treminalu, trenutne pozicije npr. dizalica, utvrđuje zahtjeve za prekrcajnim sredstvima te provodi i kontrolu RFID (radiofrekvencijskih) komponenti.
- *Equipment PLC's/SCADA* (System Control and Data Acquisition) –- sustav za praćenje i kontrolu opreme, osobito automatski navođenih prekrcajnih vozila putem programabilnog logičkog kontrolera (PLC) te SCADA (System Control and Data Acquisition) sustava za prikupljanje i analizu podataka u stvarnom vremenu.
- *Information Technologies-Analysis and Design* – sustav za dizajniranje i analizu informacijsko-komunikacijskih tehnologija – zajednički svim sustavima, zadužen za analizu svih elemenata hardvera i softvera, djeluje na poboljšanje trenutnih performansi, prati kvarove te analizira učinke primjene određenog softvera.

Svaki od ovih sustava mora biti povezan s adekvatnom bazom podataka. Točni i brzi podaci ključni su za uspješan rad ovih sustava. Jedan od načina stvaranja pouzdane baze podataka je klasifikacija podataka i upravljanje životnim ciklusom informacija.

Upravljanje životnim ciklusom informacija je održiva strategija za pohranu podataka, sa svrhom balansiranja između troškova pohrane i upravljanja podacima i poslovne vrijednosti tih podataka. Klasifikacija podataka je proces koji definira razne karakteristike podataka grupirajući ih u logičke kategorije, kako bi se olakšalo postizanje poslovnih ciljeva [14, str. 558.]. Ispravno ustrojene baze podataka trebale bi služiti kontejnerskim terminalima kao i svim ostalim subjektima lučke zajednice (Port Community System).

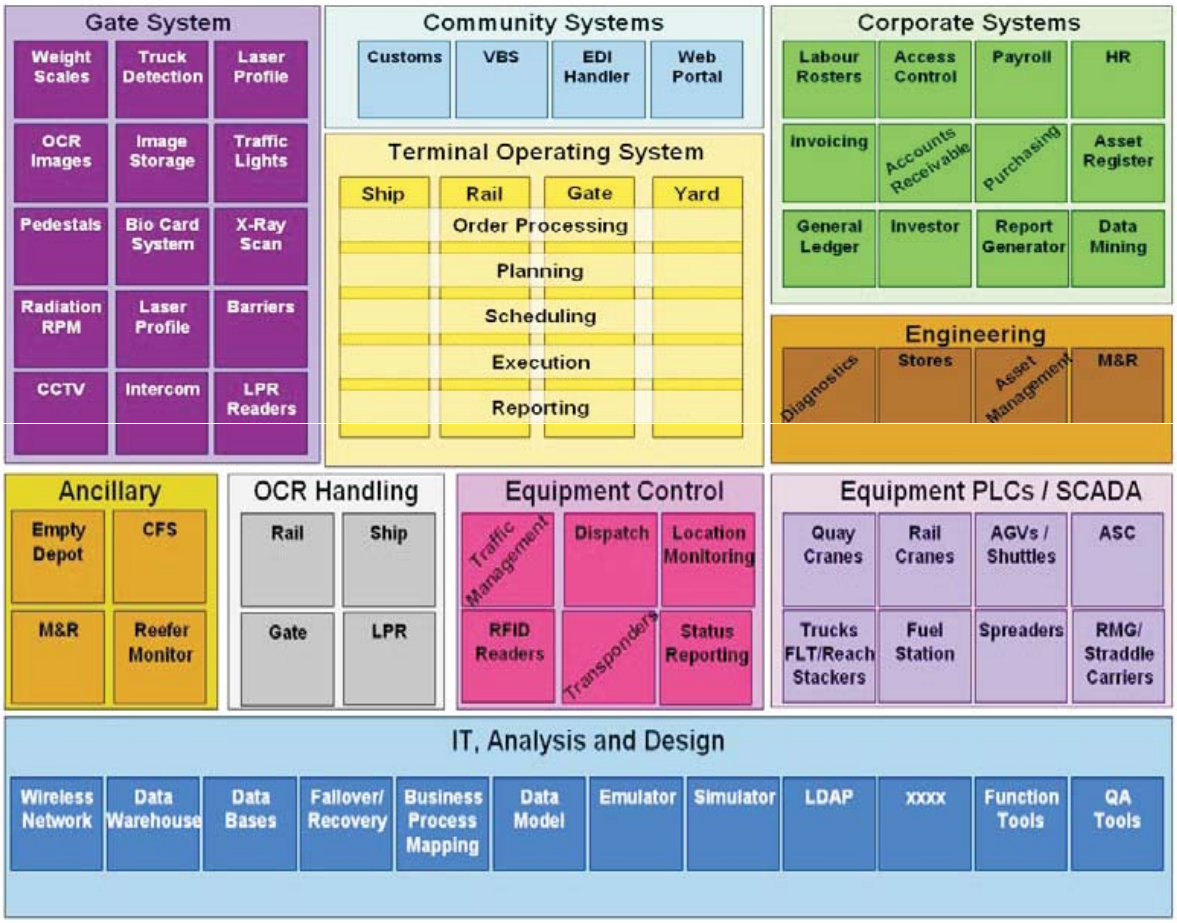
- *OCR Handling System*: charged for logistic packaging and Optical Character Recognition of cargo in order to prepare the cargo for transport.
- *Equipment Control System*: controls the position and schedule of the equipment, the functioning of RFID readers and creates reports.
- *Equipment PLC's/SCADA System*: one of the most important systems. Manages the cranes, especially the Automated Guided Vehicles by a PLC (Programmable Logic Controller) and SCADA (Supervisory Control and Data Acquisition).
- *IT Analysis and Design*: this system is superior to all systems because it analyses and designs important components of the IT systems such as data bases, wireless networks, LADAP (Lightweight Directory Access Protocol) with the purpose not just to establish IT systems, but for a continuous improving of and quality assurance as well.

All these systems must be supported by a proper data base. Accurate and prompt information is the foundation for an adequate functioning of any of the above mentioned ICT systems. One way of dealing with that issue is Data Classification and Information Lifecycle Management.

The ILM is a sustainable storage strategy suited to balance the costs of information storage and governance with its business value that changes as the process is being developed and implemented. The DC paradigm is a process that defines the access, recovery and discovery characteristics of an enterprise's (in this case, PCS's) different sets of data, grouping them into logical categories to facilitate business objectives [14, p. 558]. A proper data base will serve the container terminal as well as all subjects of the Port Community.

4.1. ICT systems for the management of automated loading/unloading equipment

Automated transfer vehicles (ATV's) are one of the most obvious examples of the importance of information and communication technologies in container terminals. They greatly facilitate the work, replacing the human resources required for the transhipment activities, in accordance with the predetermined re-



Slika 1. Računalna mapa operatora kontejnerskog terminal [6, str. 4.]
Figure 2. *Terminal Operator Computer Systems Maps* [6, p. 4]

4.1. ICT sustavi za upravljanje automatiziranim prekrcajnim sredstvima

Automatizirana prekrcajna sredstva jedan su od najznačajnijih primjera važnosti primjene informacijsko-komunikacijskih tehnologija na kontejnerskim terminalima. Uvelike olakšavaju rad i zamjenjuju ljudske resurse potrebne u prekrcajnim aktivnostima, a sve prema unaprijed određenim zadacima isplaniranim TOS sustavom. Omogućuju visok stupanj protoka tereta i znatno smanjenje vremena opsluživanja brodova.

Povezanost TOS-a i upravljačkog sustava dizalice (Crane Control System) uvjetovana je stupnjem automatizacije dizalice. Ukoliko se radi o potpuno automatiziranoj dizalici zahtijeva se direktno slanje radnih naredbi od strane TOS-a prema dizalici, te primanje povratnih informacija od dizalice. Ukoliko se radi o poluautomatiziranim dizalicama u čijem radu sudjeluje operator, alternativa je da se naredbe unose u računalo te tako šalju prema dizalici [9, str. 54.].

quirements planned by the TOS system. ATV's allow a higher flow of containers and significantly reduce the time needed for serving ships.

Connectivity between the TOS and Crane Control System depends on the degree of the automation of cranes. If the crane is fully automated, it is necessary to send work orders directly from the TOS to the cranes and get the information back from the crane. If the crane is semi-automated, the alternative for the operator is to enter the commands into the computer, and then the computer sends them to the crane [9, p. 54].

Consequently, the company "ABB AB Crane System" has developed a special software called "ABB Application Layer Protocol". The message that is received from the TOS is processed to the crane as information from which a working task will then be formed, or as a request for the information about the completed actions. ABB protocol may be associated with TOS in two ways [9, p. 70]:

Slijedom toga tvrtka "ABB AB Crane System" razvila je poseban softver nazvan "ABB Aplication Layer Protocol". Poruka koja se prima od TOS-a obrađuje se i šalje dizalici kao informacija iz koje se formira radni zadatak ili zahtjev za informacijom o izvršenim zadacima. ABB protokol može biti povezan s TOS-om na dva načina [9, str. 70.]:

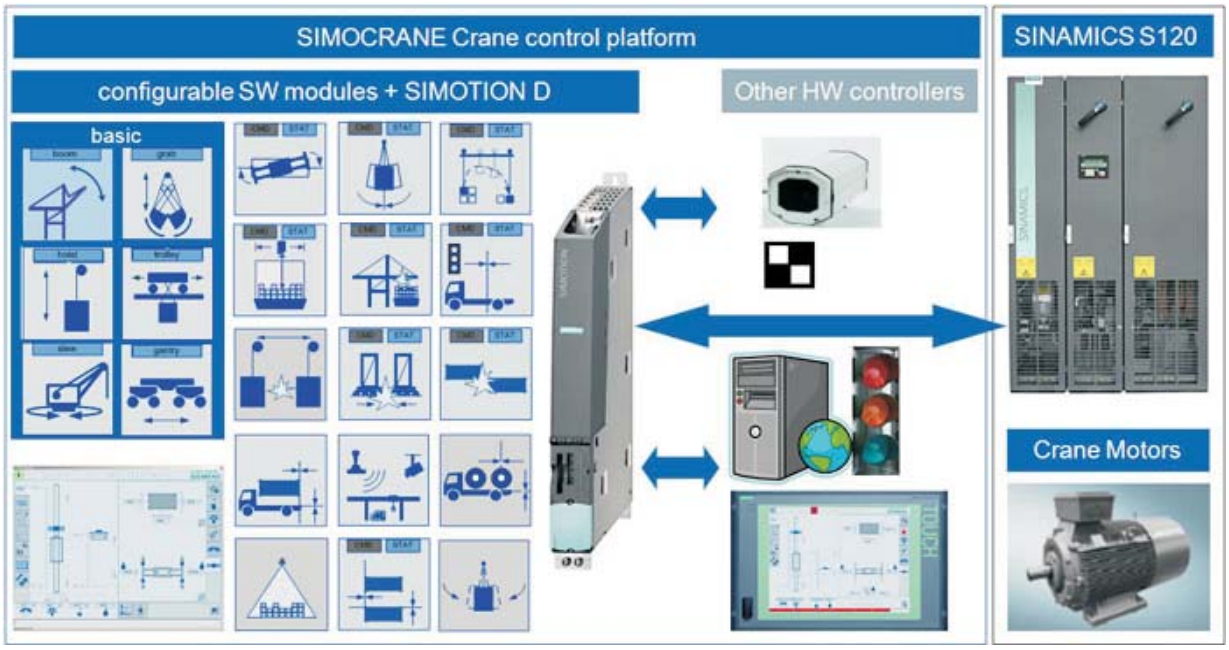
1. Kao dio TOS-a (primjerice na Euromax kontejnerskom terminalu, u luci Rotterdam-standardu za moderne i logistički orijentirane kontejnerske terminale);
2. Putem dodatnog softvera koji će poruke TOS-a dekodirati u poruke razumljive ABB protokolu (primjerice na Taipei Port kontejnerskom terminalu u Tajvanu).

Svaki proizvođač automatiziranih dizalica mora razviti vlastiti softver s upravljačkim naredbama vodeći računa o mogućnosti povezivanja s TOS sustavom. Najveći pomak učinila je tvrtka Simens razvojem nekoliko tipova softvera od kojih je najvažniji i najnapredniji SIMOTION D ili SIMOCRANE. To za korisnika, tj. kupca bilo koje vrste dizalica jamči standardizaciju upravljačkih i kontrolnih naredbi neovisno o proizvođaču. Proizvođači su dobili mogućnost izbora integriranja softvera u svoje dizalice: integrirati samo SIMOCRANE ili koristiti SIMOCRANE u kombianaciji s vlastitim softverom.

1. As part of TOS (for example used by a Euromax container terminal - terminal in the port of Rotterdam – a standard for modern logistics oriented container terminals)
2. Using additional software to send messages to TOS and decode the protocol understood by ABB (for example used by Taipei Port Container Terminal in Taiwan)

Each manufacturer of automated cranes must develop its own software to control orders, taking into account the possibility of connecting with the TOS. The biggest shift was made by the company Siemens with the development of several software products. The most important and most advanced is SIMOTION D or SIMOCRANE. To the user, i.e. the buyer of any type of crane, the software ensures standardization and control commands, and independence of performance by the crane manufacturer. The Manufacturers were given a choice of integrating the software into their products: integrated only with SIMOCRANE or combined with their software.

Management and control functions are standardised by picture symbols. (Figure 3)



Slika 2. SIMOCRANE softver
Figure 3. *SIMOCRANE software*

Izvor/*Source*: http://www.automation.siemens.com/mcms/mc/en/mechanical-engineering/crane-solutions/simocrane/Pages/simocrane.aspx.

Upravljačke i kontrolne funkcije standardizirane su slikovnim simbolima (Slika 2).

4.2. Sustavi identifikacije i praćenja kontejnera

Evolucijom informacijsko-komunikacijskih tehnologija omogućen je razvoj sustava za identifikaciju i praćenje kontejnera. Važnost ovih sustava proizlazi iz potrebe za nadzorom nad kontejnerom i njegovim sadržajem u luci te za praćenjem kontejnera od ishodišta do odredišta [8, str. 76.].

Za luku, najvažniji vrijeme identifikacije i praćenja nastaje dolaskom kontejnera u lučko područje. Jedna od najčešće korištenih tehnologija identifikacije je RFID (Radio Frequency Identification Technology), tehnologija temeljena na principu bežičnih čitača. Čitači pomoću radiovalova očitavaju najvažnije informacije o kontejneru i koriste se najviše kada se kontejneri odlažu na slagalište. U nekim slučajevima pravi sadržaj kontejnera ne odgovara opisu u dokumentima i čitačima. Korištenjem rendgenskih (X-ray) skenera skenira se cijeli sadržaj kontejnera na principu rendgenske snimke. Kao nadopunjujući sustav koriste se Heartbeat detektori (detektori otkucaja srca) za detekciju živih bića u kontejneru.

Korisnici su ključni subjekt dobavnog lanca, stoga njihove želje nisu više ograničene samo na smanjenje troškova, nego žele biti upoznati i sa statusom svoje pošiljke u svakom trenutku. Da bi se uspješno odgovorilo na zahtjeve korisnika osmišljen je cijeli sustav upravljanja nazvan Customer Relationship Mangement – Upravljanje odnosima s kupcima (korisnicima). Takav moderan sustav se temelji na bazi podataka povezanoj internet aplikacijama s korisnicima i svim subjektima dobavnog lanca. Subjekti primaju i šalju informacije u bazu podataka te su im na raspolaganju svi podaci vezani za njihove pošiljke - mjesto, vrijeme, moguće komplikacije i sl. Sustavi upravljanja odnosima s korisnicima povezani su sa sustavima za direktno praćenje kontejnera kao što je GPS (Global Positioning System) - globalni pozicijski sustav (jedan od novijih sustava temeljen na satelitskoj tehnologiji). Sustav minimizira mogućnost gubitka kontejnera i omogućuje kontinuirano praćenje kontejnera i na kopnu i na moru.

4.2. Container identification and tracking systems

ICT evolution enabled the development of efficient systems for the identification and tracking of containers. The importance of these ICT systems arises from requirements for the identification of containers and their content within the port area and tracking containers from the starting point to the point of destination. [8, p. 76]

From the port perspective, the most important identification of a container starts at the time when a container arrives in the port area. One of the mostly used systems for that purpose is RFID technology (Radio Frequency Identification Technology) which is based on radio waves. A special RFID reader reads the basic information about the cargo and serves primarily for the handling of containers in the stowage area. Sometimes the real content of containers does not match the content stated in documentation. X-ray scanning inspects the whole container content by using the principle of Rontgen scanning. As an extension of X-ray scanning, Heartbeat Detectors are being used for detection of any living organisms within containers.

Customers, who are the key for managing the supply chain have needs which are now not just limited to reducing costs and to faster fulfilment of orders, customers also want to be informed about every aspect of delivery, they want to know what is the status of their goods at any given moment. To respond to the customer's needs, a whole management system was designed and called Customer Relationship Management, and seaports integrated this approach in their businesses. The system functions as a data base which is connected by Internet applications with customers and all subjects of the port supply chain. All subjects involved send and receive the information from the data base. Subjects can get all kinds of information and they know the complete status of their goods - place, time, possible complications, operations etc. The Customer Relationship Management systems are connected with several systems for direct tracking of containers such as the Global Positioning System (GPS). The Global Positioning System is one of the most innovative systems based on satellite technology. The usage of this system provides the possibility to prevent the loss of containers and provides continuous tracking, equally in inland or sea transport.

4.3. Računalne simulacije na kontejnerskim terminalima

Metoda računalnog simuliranja vrlo je korisna i učinkovita metoda za planiranje izgradnje kontejnerskih terminala i svih aktivnosti na kontejnerskom terminalu (planiranje opreme, planiranje kapaciteta, proračun propusne i prihvatne moći, izračun troškova i sl). Organizacija "Institute of Shipping and Logistics" prepoznala je važnost računalne simulacije za kontejnerske terminale te je osnovala simulacijski centar "SimulationTraining Centre" [10, str. 82.]. ISL-ov sustav simulacije sastoji se od sljedećih podsustava:

- *CRASY (Crane Simulation System)* – simulira rad dizalica i ostalih prekrcajnih sredstava kako bi se utvrdilo karakteristike određenih tipova dizalica, brzina njihovog rada i maksimalne prekrcajne mogućnosti.
- *SCUSY (Simulation of Container Handling Unit System)* – simulira količinu prekrcaja kontejnera te sve pokrete kontejnera.
- *CAPS (Capacity Plannig System-container terminal)* – simulira maksimalnu prihvatnu i propusnu moć terminala.
- *i.e. MS Excel (Matemathical calculations)* – izračunava ekonomske aspekte rada kontejnerskog terminala.
- *ConRoCAPS (Capacity Planing System – combined Operation Ro-Ro/CT)* – simulira kombinirane ro-ro i kontejnerske operacije.
- *VITO (Virtual Terminal Optimiser)* – simulira korištenje novih strategija, novog softvera i novih tehnologija.

Svaka veća i modernija kontejnerska luka koristi računalne simulacije pri izgradnji i rekonstrukciji kontejnerskih terminala u svrhu detaljnog planiranja poslovnih procesa i sprječavanja neprofitabilnih investicija.

5. VIRTUALNA LOGISTIKA NA KONTEJNERSKIM TERMINALIMA

Razvojem moderne logistike i potrebe za smanjenjem transportnih troškova uz velike mogućnosti informacijsko-komunikacijskih tehnologija, došlo je do pojave i razvoja tzv. virtualne logistike, koja je već implementirana u nekim većim kontejnerskim lukama (Rotterdam,

4.3. Computer simulation in container terminals

Computer simulation is a very useful and efficient method in the planning of all activities in container terminals: building, setting equipment-especially cranes, planning capacities, etc. The Institute of Shipping and Logistics (ISL) recognized the importance of computer simulations and founded the "Simulation Training Centre" [10, p. 82]. ISL's simulation system consists of the following subsystems:

- *CRASY (Crain Simulation System)*: analysis of any types of ship to shore crane systems - plans optimum vessel dispatch.
- *SCUSY (Simulation of Container Handling Unit System)*: simulates and analyses terminal operations by simulating the interactions of the container terminal handling equipment.
- *CAPS (Capacity Planning System)*: simulates capacities of surfaces or equipment in container terminals to increase productivity.
- *I.e. MS Excel (Mathematical Calculations)*: calculates costs of buying equipment or cost of any building and reconstruction.
- *ConRoCaps (Capacity Planning System-combined operation RO/RO CT)*: simulates capacities and productivity in combined RO-RO operations.
- *VITO (Virtual Terminal Optimiser)*: simulates the usage of new strategies, new equipment, and new technologies.

When building and reconstructing container terminals, every large and modern container port uses computer simulation methods to plan every detail of the business process in order to prevent the loss of time and money on unproductive investments.

5. VIRTUAL LOGISTICS IN CONTAINER TERMINALS

The strong evolution of logistics and the need for decreasing the transportation costs and improving the order processes, in accordance with the possibilities of the IT systems, has led to the evolution of Virtual logistics which is already implemented in large container ports (Port of Rotterdam, Port of Hamburg, Port of

Hamburg, Singapur, Jabel Ali). Virtualna logistika obrađuje fizički i informacijski aspekt logističkih operacija. Vlasništvom i kontrolom resursa upravlja se putem internet aplikacija [11, str. 73.]. Postojanje velikog broj specijaliziranih tvrtki koje se bave pružanjem usluga u virtualnoj logistici pretpostavlja neizbježnu upotrebu virtualne logistike na kontejnerskim terminalima u budućnosti.

Orijentacija kontejnerskih terminala na sustav virtualne distribucije, virtualnih skladišta i virtualnih zaliha omogućuje značajne uštede u vremenu i trošku isporuke uspostavljanjem distribucijskih centara blizu korisnika i korištenjem informacijskih tehnologija.

Prednosti koje korisnik usluga i sam kontejnerski terminal mogu ostvariti primjenom virtualne logistike prikazane su u tablici 1. Uspoređena je struktura dobavnog lanca 80-tih godina dvadesetog stoljeća temeljena na regionalnim distribucijskim centrima i struktura dobavnog lanca 90-tih godina dvadesetog stoljeća temeljena na europskim distribucijskim centrima po principu virtualne logistike [4, str. 4.]. Kriteriji za usporedbu su: vrijeme od narudžbe do isporuke, raspoloživost proizvoda, trošak zaliha, dolazni i odlazni troškovi prijevoza te troškovi skladištenja.

Vrijeme od narudžbe do isporuke značajno je reducirano, sa 3 – 5 dana na 1 – 3 dana u virtualnoj logistici. Raspoloživost proizvoda je pomaknuta s regionalne razine na potpunu raspoloživost. Troškovi zaliha i dolazni transportni troškovi znatno su manji u virtualnoj logistici,

Singapore, and Port of Jebel Ali). Virtual logistics handles the physical and the informational aspects of logistics operations. Ownership and control of resources is managed by using the Internet applications [11, p. 73]. There are a number of specialized companies that are engaged in providing the services in Virtual logistics. Virtual logistics is the inevitable future of container terminals.

The orientation of container terminals at systems of virtual distribution, virtual storage or virtual store allows significant savings in time and cost of delivery by establishing the distribution centres closer to the customers and by using the ICT. The advantages for the customers and container terminals achieved by the usage of Virtual logistics are shown in Table 1.

The example compares supply chain structures in the 1980's based on Regional Distribution Centres and the 1990's based on European Distribution Centres based on Virtual Logistics. The criteria for comparison are: lead time, stock availability, inventory costs, inbound transportation costs, outbound transportation costs and warehousing costs [4, p. 4].

In Virtual warehousing, the lead time is significantly reduced, from 3-5 days to 1-3 days. Stock availability is removed from the regional in RDC's to complete in EDC's and VW's. Inventory costs and inbound transportation costs are very low in VW's, but outbound transportation costs are consolidated in accordance with the VW's principle of few different goods in one shipment. Warehousing costs are higher

Tablica 1. Prednosti korištenja virtualne logistike na kontejnerskim terminalima [4]
Table 1. *The advantages of using the Virtual Logistics in container terminals* [4]

STRUKTURA DOBAVNOG LANCA *SUPPLY CHAIN STRUCTURE*	RDC (80's)	EDC (90's)	VW (00's)
Vrijeme od narudžbe do isporuke *Lead time*	<3-5 dana *<3-5 days*	<3-5 dana *<3-5 days*	<1-3 dana *<1-3 days*
Raspoloživost proizvoda *Stock availability*	Regionalna *Regional*	Potpuna *Complete*	Potpuna *Complete*
Trošak zaliha *Inventory costs*	Visok *High*	Nizak *Low*	Nizak *Low*
Dolazni trošak prijevoza *Inbound transportation costs*	Visok *High*	Konsolidiran *Consolidated*	Nizak *Low*
Odlazni trošak prijevoza *Outband transportation costs*	Nizak *Low*	Visok *High*	Konsolidiran *Consolidated*
Trošak skladištenja *Warehousing*	Visok *High*	Nizak *Low*	Visok *High*

dok su odlazni transportni troškovi konsolidirani s obzirom na veći broj manjih pošiljaka objedinjenih u jednoj. Takvo značajno smanjenje vremena ispunjenja narudžbe i ukupnih troškova potiče korisnike na veće korištenje usluga kontejnerskih terminala, a slijedom toga privlači se više tereta u određenu luku.

Korisnik može u svakom trenutku, jednostavnim korištenjem internet aplikacija, znati sve potrebne podatke o količini i dostupnosti robe koja se nalazi na samom kontejnerskom terminalu, koja je otpremljena iz kontejnerskog terminala ili koja se doprema na kontejnerski terminal. Na slici 3. prikazan je sustav virtualne logistike, tj. virtualnog skladišta kojeg provodi "Oceangate Distribution" logistički operator [1, str. 26.].

Potrebno vrijeme stizanja roba od proizvođača do krajnjeg korisnika koji se nalazi u Europi iznosi 45 dana. Najvažniji fragment toga vremena je razdoblje u kojem roba nakon što stigne u Europu, odnosno kada se iz luke dopremi u distribucijske centre, provede na putu od distribucijskog centra do krajnjeg korisnika. U ovome slučaju, korisniku je roba iz distribucijskog centra isporučena za jedan dan. U svakom dijelu toka robe od ishodišta do odredišta korisnik je imao uvid u količinu i dostupnost robe.

Gledajući sa stanovišta korisnika usluga kontejnerskih terminala, prednosti korištenja virtualne logistike, tj. virtualnih skladišta su [2, str. 21.]:

– kraće vrijeme isporuke

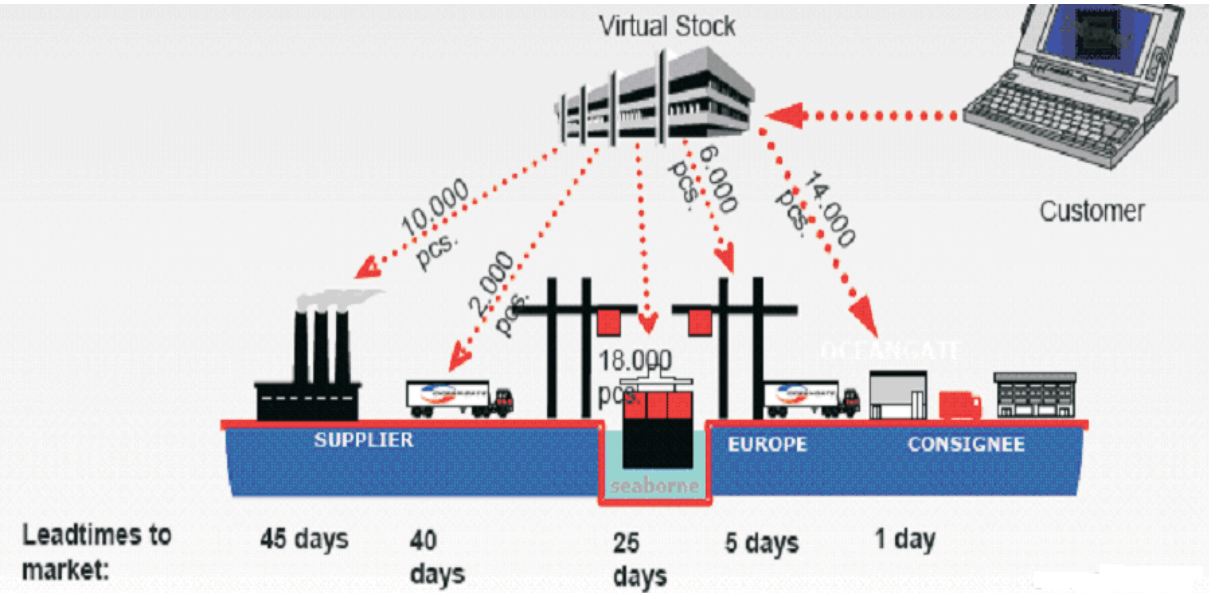
than in EDC's according to the number of DC's. Such significant reduction in the time of fulfilment of an order and in the total cost encourages a greater use of the container terminal services and, consequently, attracts also more cargo to a port.

The user can at any time, simply by using Internet applications, know everything about the quantity and accessibility of goods which may be located at the container terminal, transported from the container terminal or delivered to the container terminal. In Figure 4 the Virtual Logistics System is shown i.e. the virtual storage conducted by the "Oceangate Distribution" logistics operator [1, p. 26].

The necessary time to reach the goods from manufacturers to the end user located in Europe is 45 days. The most important fragment is the time that the goods which arrived in Europe and which the port delivered to the distribution centres, spend on the road from the distribution centre to the end user. In this case, customers get their goods from the distribution centre just in one day. In every part of the flow of goods, from the origin to the destination point, the user has had an insight into the amount and availability of the goods.

From the point of view of the users' of the container terminal services, the benefits of using Virtual logistics (virtual storage) are [2, p. 21]:

– shorter delivery time



Slika 3. Oceangate sustav virtualne distribucije [1]
Figure 4. *Oceangate Virtual Distribution System* [1]

– pregled dostupnosti robe putem Internet aplikacija
– bolja dostupnost robe u distribucijskim centrima bliže korisnicima
– smanjenje mogućnosti oštećenja robe izbjegavanjem otvaranja kontejnera u regionalnim centrima
– homogeniziran prijevoz
– standardizacija pakiranja.

Cijeli sustav mora biti temeljen na prikladnim informacijsko-komunikacijskim tehnologijama, razumljiv svim subjektima koji ga koriste. Virtualna logistika ima neupitne prednosti u upravljanju logističkim resursima te će u budućnosti sigurno postati dio poslovanja naprednijih kontejnerskih terminala.

6. ZAKLJUČAK

Kontejner kao jednostavni metalni spremnik različitih izvedbi omogućio je brz uspon pomorskog prometa unutar svjetske trgovine, prije svega zbog pouzdanog i ekonomičnog načina prijevoza. Razvojem kontejnerizacije, napretkom informacijsko-komunikacijskih tehnologija te evolucijom logistike, kontejnerski terminali su postali centri tehnologije, znanja i informacija.

Operatorima kontejnerskih terminala na raspolaganju su različiti informacijsko-komunikacijski sustavi kojima se mogu detaljno isplanirati sve aktivnosti i osigurati pravilan rad cijelog kontejnerskog terminala, koji će se tada povoljno reflektirati na cijelu lučku zajednicu i omogućiti pružanje kvalitetne usluge koja vodi zadovoljenju potreba korisnika. Najvažniji sustav za planiranje prekrcajnih aktivnosti na kontejnerskim terminalima je TOS (Terminal Operating System). TOS sustavom detaljno se analiziraju kontejneri prema svojim obilježjima i u skladu s time planiraju potrebni resursi za prekrcajne aktivnosti te sam proces prekrcaja. Procese isplanirane TOS sustavom obilježava visok stupanj učinkovitosti koji direktno utječe na produktivnost i rentabilnost kontejnerskog terminala.

Napredak informacijsko-komunikacijskih tehnologija, zahtjevi logističkih procesa i rastuće potrebe korisnika doveli su i do razvoja nekih vrlo specifičnih računalnih metoda kao npr. računalnih simulacija, do primjene GPS sustava

– overview of the availability of goods via Internet applications
– better availability of goods in distribution centres nearer to the customer
– decreased possibility of damage to the goods by avoiding unpacking of containers in the regional centres
– homogenized shipment
– standardization of packaging

The whole system must be based on the appropriate ICT, acceptable and understandable to all subjects involved. Virtual Logistics possesses unquestionable advantages in managing the logistic resources. Virtual Logistics will certainly become an integral part of business for advanced container terminals.

6. CONCLUSION

A container, as a simple reusable metal storage unit in several different varieties, enabled the swift growth of maritime traffic within the world trade as a reliable and inexpensive means of transportation. With the development of containerisation, the progress of ICT and the evolution of logistics, container terminals have become the centres of technology, knowledge and information.

Terminal operators have different ICT systems available, systems that can thoroughly plan all activities and ensure the proper functioning of the entire container terminal. This will then reflect favourably on the entire port community and enable the provision of quality services that meet the needs of the users. The most important is the system for planning transhipment activities in container terminals called Terminal Operating System (TOS). TOS provides a detailed analysis of containers according to their characteristics, and in accordance with that TOS plans the resources needed for transhipment activities and processes. Processes planned by TOS are marked by a high degree of efficiency that directly affects the productivity and profitability of container terminals.

The progress of ICT and the requirements of logistics processes, as well as the increased customer's needs and expectations, have led to the development of some very specific methods such as computer simulation, usage of GPS in

u praćenju kontejnera i sl. Računalne simulacije omogućuju predvidljivost u izgradnji kontejnerskih terminala, planiranju svih aktivnosti te izračunu ekonomskih aspekata rada kontejnerskih terminala. Različiti sustavi identifikacije i praćenja kontejnera olakšavaju utvrđivanje sadržaja kontejnera i praćenje kontejnera unutar i izvan lučkog područja.

Kao poseban oblik sinergije informacijsko-komunikacijskih tehnologija i logistike javlja se virtualna logistika koja implementacijom na kontejnerske terminale može minimizirati vrijeme ispunjenja narudžbe i troškove prijevoza robe od proizvođača do krajnjeg korisnika. Korisnicima usluga kontejnerskih terminala virtualna logistika, osim kraćeg roka isporuke, omogućuje da jednostavnom uporabom internet aplikacija ostvare uvid u status svoje pošiljke tijekom cijelog njezinoga puta. Virtualna logistika, s nizom neupitnim prednosti, trebala bi postati preferirani način poslovanja kontejnerskih terminala.

tracking containers, etc. Computer simulations provide the needed predictability in the construction of container terminals, planning of all activities and calculation of economic aspects of container terminals. Different systems of identification and tracking of containers facilitate the inspection of container contents and tracking of containers within and outside the port area.

A special form of synergy of ICT and logistics is virtual logistics. By utilizing Virtual logistics, container terminals can reduce the time needed to fulfil orders and reduce the transportation costs from the producer to the end-user. To users of container terminal services, beside a shorter delivery time, Virtual logistics allows an insight into the status of their shipments throughout the route by using Internet applications. Virtual Logistics, with unquestionable advantages, should become the preferred mode of operation in container terminals.

LITERATURA / REFERENCES

[1] Ahlf, B., Intergrated port container distribution logistics supported by electronic applications at a hub-port, Port of Hamburg, http://www.e-logistics.com.cn/eLogmarm/hope/pdf/Ahlf_Speech.pdf

[2] Charlesworth, D., Strategies for the development of port-centric logistics, TOC Conference, Amsterdam 2008.

[3] Ismail A. R., et al., Implementation of EIS : a study at Malaysian SMES, European Journal of Scientific Research, 30 (2009), 2.

[4] Jeroen van der Berg Consulting: Virtual warehousing, Netherland, 2001., http:// www.idii.com/wp/jvd-virtual-warehousing.pdf

[5] Container terminals and cargo systems : design, operations management and logistic control issues, New York, Springer, 2007.

[6] Martin, J., International port training conference : developing skills for terminal automation, p.2., www.iptc-online.net/scroll/documents/JeffMartin.pdf

[7] Miesel, F., Seaside operations planning in container terminals, New York, Physica Verlag, Springer, 2009.

[8] Port Technology International: Integrated Check-in and Security System Above ISPS Code Compliance, Edition 41, 2009.

[9] Port Technology International: Modern Interface between TOS and Crane Control System, Edition 41, 2009.

[10] Port Technoloy International: Optimising Container Terminals Using Simulation and Emulation Methodology, Edition 41, 2009.

[11] Protrka, R., Virtualna logistika, Tehnički glasnik, 3 (2009), 2.

[12] Pupavac, D., Optimalizacija proizvodnje unutar logističkog lanca za 21. stoljeće, Zbornik radova Ekonomskog fakulteta u Rijeci, 24 (2006), 2, str. 291-304.

[13] Tijan, E., S. Kos, D. Ogrizović, Disaster recovery and business continuity in port community systems, Pomorstvo, 23 (2009), 1, str. 243-260.

[14] Tijan, E., Data clasiffication and information lifecycle management in port community systems, Pomorstvo, 23 (2009), 2, str. 557-568.