Good Practices in Information and Communication Technology (ICT) Applications in Seaports in ESCWA Member Countries

United Nations
Economic and Social Commission for Western Asia

ECONOMIC AND SOCIAL COMMISSION FOR WESTERN ASIA (ESCWA)

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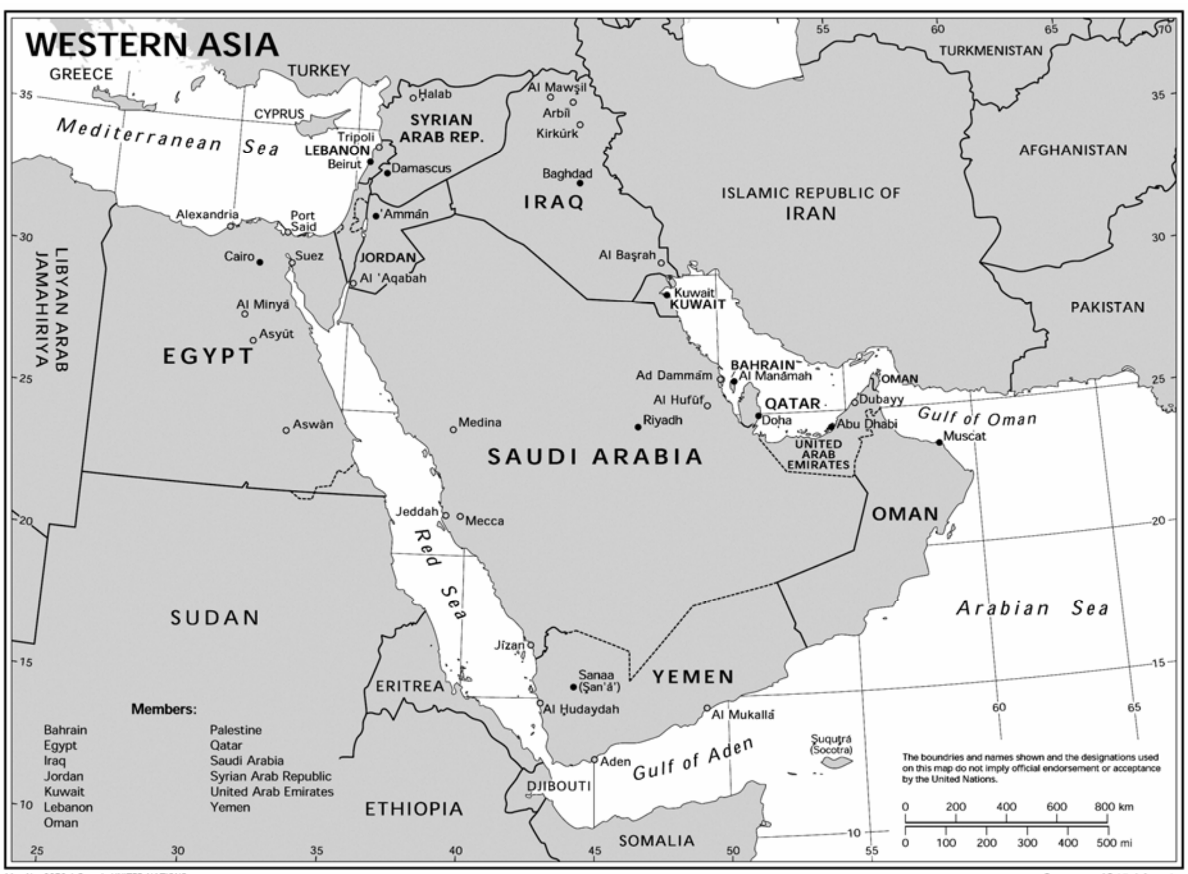

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The views expressed in this *Study* are those of the authors and do not necessarily reflect the views of the United Nations Secretariat.

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Abstract

Using information and communications technology (ICT) in ports is essential to ensure accurate, real-time control and pre-planning for the various port management operations. ICT applications benefit trade facilitation at a port through decreasing time, cost and human error during vessel and cargo operations.

Many ports throughout the world are applying ICT in their communities. The three most common structures are central database or port operating system, message exchange broker and combined system. This *Study* selected the combined system as the recommended architecture for ports in the ESCWA member countries, the reason being the system relies on the message exchange broker as the initial module, with a subsequent gradual extension of services and applications.

Before applying an ICT solution for port management, many administrative, technical and budgetary factors should be carefully studied and evaluated to ensure the targeted objectives and goals set out by the port authority and other members of the port community are being achieved, and that future developments and trends can be accommodated to meet the demands of an evolving environment.

For successful ICT application, a detailed study on the planned, re-engineered and automated workflow for the various vessel, cargo and gate operations is required. A second study is recommended on the anticipated ICT infrastructure needs, including civil work and hardware and network facilities to suit the planned system and facilitate a smooth workflow throughout all operations. Numerous business and technical elements require careful consideration prior to implementation to ensure that the targeted objectives and goals are being met, and that the system can be upgraded in response to technological developments and future trends.

The manual, paper-based handling and transmission of information is possibly the biggest bottleneck and the greatest source of errors and delays in international trade and transport. Port communities, including customs authorities, should implement electronic data interchange (EDI) technologies in order to improve the flow of information, allowing for pre-arrival submission of manifest information and better risk management, as required by most important trading nations. Ports and customs authorities should make use of the Internet and the web to become transparent in their operations and provide users with all the essential information on regulations, procedures, facilities, contacts and tariffs.

Several software solutions are available for effective port and terminal operation, providing the main required services for planning and controlling vessel, cargo and gate operations, in addition to performing all billing services related to such operations. Furthermore, specific ICT tools are required for message and data exchange services between various port community entities, for data warehousing and for portal services.

A number of ESCWA ports have successfully applied various terminal operating systems. For example, in the United Arab Emirates, Dubai Ports (DP World) have developed a container management system with two software applications for all container terminal activities at Port Rashid and Jebel Ali Port. Alexandria Port Authority, Egypt, has implemented an ICT system that integrates all port community members through a message exchange broker. For the control of vessel and cargo operations, each entity is provided with an online system for exchanging real-time messages with other related entities. In addition, other ports in the region have also developed and implemented ICT systems, including Port of Beirut, Lebanon; Damietta Port in Egypt; Port Sultan Qaboos and Port of Salalah in Oman; and Port of Aqaba in Jordan.

Introduction

More than ever before, automation technologies, especially information and communications technology (ICT), are impacting virtually every aspect of life. From a data-processing tool in the 1970s and 1980s, ICT has evolved into a productivity component in strategic management.

There is a general awareness, not only at major, highly automated seaports, but also at smaller and medium-sized ports, that productivity and quality of port operations and related services are directly linked to the speed and accuracy at which both physical and administrative tasks are carried out. In order to achieve accelerated cargo and container handling times and greater organizational reliability of the transport chain from end to end, it is important to modify the business parameters. Improved conditions have to be established for the handling of goods and the reception of the various modes of transport, not only in terms of infrastructure and equipment, but also when it comes to ICT. The investment in innovative, intelligent technologies is an essential step towards meeting market demand and guaranteeing competitiveness. ICT is regarded a vital instrument in achieving substantial improvements in internal and external business procedures, mainly through the implementation of port and terminal operating systems and electronic data interchange (EDI). Such technologies and operating systems are costly to design, implement and run; therefore, proper justification must be given for the large investment required.

The decision to invest in ICT and other technologies, particularly the implementation of EDI between various entities involved in port operations, for example shipping agencies and customs authorities, requires careful consideration and should be based on thorough analysis and assessment of the commercial and technical impact and constraints. The implementation of an ICT community with a port being the key partner is lengthy and comprehensive; however, the long-term objective is to create a well-functioning and, ultimately, paperless operational and administrative environment.

The aim of implementing ICT in port operations is to attain the following benefits:

(a) Faster turnaround of vessels and improved speed of various port operations; with computer-aided planning and EDI-facilitated communication, precise and timely information on container and cargo location and movement is ensured, in turn resulting in cost-effective management of inventory;

(b) Faster and more accurate communication between entities of the port community; transmission of operational information using EDI and the Internet results in seamless communication across the globe, leading to less lead time requirement for shipping-related documentation and accurate information for planning;

(c) Increased productivity gained through efficient equipment, space and human resource deployment; for example, efficient crane and equipment assignment and effective preventive maintenance planning result in better return on investment;

(d) Enhanced security, with physical security aided by better information on commodities, shippers, consignees and trade routes, and information security ensured through security systems, firewalls and logical control;

(e) Better structured management and business process flows and performance measures, leading to improved management of cost-of-service delivery.

All the above factors, in turn, are expected to lead to better scale economy, lower operating costs and greater customer satisfaction. With appropriate ICT application at seaports, not only will port efficiency be enhanced and market reach broadened both locally and globally, but also the national economy of the country and its various sectors will benefit. Stakeholders recognize that a strong Government role in ICT promotion and implementation is required, and they stand ready to work with Governments to act on international recommendations and address the wide range of challenges facing the port industry in order to achieve results. World trade is on a sharp increase, and with most of that trade being carried by ships and handled by ports, preparations are necessary to be able to partake and benefit from such progress, including maximizing the effectiveness of newly-implemented initiatives and speeding up efforts to meet various national and global goals and targets.

The general purpose of this *Study* is to identify the latest developments in ICT applications at major seaports worldwide and in port operations in the ESCWA region. Furthermore, regional trade and transport benefits and the approach to choice and implementation of software solutions are discussed in order to encourage wider ICT application. The objective is to provide ESCWA member countries with an in-depth study on ICT good practices in port operations and, through a case study of a model port, present how best to make use of such tools and practices.

The *Study* explains the importance of ICT applications in the management and operation of seaports and presents a careful analysis of ICT systems in use. Chapter I presents the benefits of using ICT in port operations and explains the three most commonly applied ICT port systems, detailing the software services provided by the various modules and by additional ICT tools and facilities. It also gives a comprehensive listing of infrastructure components required for implementation and operation. Chapter II includes a survey of the best known and most commonly used terminal operating systems and solutions available, in particular for container terminal operations, with a description and assessment of each approach. Furthermore, an overview of how selected ports worldwide and in the ESCWA region have applied ICT in their operations is presented. Chapter III gives a detailed description of the functions of each entity within the port community, the information they require and the data they generate to be used by other members of the community and by customers. Often, re-engineering of the existing workflow may be needed to enhance the performance of such entities. The standard re-engineering methodology, as well as that for exchanging electronic messages and data between port stakeholders, is explained, and the chapter lists the main parameters and features required for reliable and scalable operation. Chapter IV focuses on the selection process, including factors to consider when choosing an ICT solution, and presents the recommended strategy. Chapter V introduces the Port of Alexandria, Egypt, as a model ICT port in the ESCWA region, giving a full description and evaluation of each stage of the electronic management project initiated by Alexandria Port Authority.

I. ICT IN SEAPORT MANAGEMENT AND OPERATION

Using ICT in port operations is required to ensure accurate, timely and, whenever feasible, real-time information on the status of all transactions, vessel activities, cargo operations and marine services. ICT applications greatly affect trade facilitation and initiate major, overall benefits. Some of the most noted benefits are listed as follows:

(a) Decreased time and cost for vessel and cargo procedures, including vessel and cargo clearance;

(b) Better integrated port community through EDI, and better decision support through online information on past and current port operations;

(c) Decreased port congestion through gate management control;

(d) Fewer incidents of human error;

(e) Minimized and optimized operational procedures, supported with planning capabilities;

(f) Minimized vessel and cargo clearance time;

(g) Increased productivity and profitability through maximized utilization of berths and yards, as well as increased number of vessels;

(h) Improved customer satisfaction through the one-stop-shop module for customer service provision and e-service through web applications and Short Message Service (SMS).

ICT can be applied in every phase of port operation, thus affecting vessel traffic, marine and gate management, cargo terminal operations, customs procedures and document exchange.

Well-managed vessel traffic is one of the key components for successful port operation. Vessel turnaround and waiting rate, berth occupancy rate and working time at berth are parameters for measuring port productivity. For vessel traffic management, using ICT integrated with radar and automatic identification systems enables tracking of vessel movement and provides improved safety in entrance and anchorage areas, as well as along main routes to berths.

Improved berth planning and utilization can be derived through using applications that can generate automatic berth plans according to such parameters as berth depth, availability of cranes, cargo type, vessel draft and vessel arrival time, as well as through automating the notification process linking the various entities involved. Other ICT applications will result in the following benefits: (a) accurate reporting on port traffic conditions, especially important during poor weather; (b) accurate reporting on vessel status, movement and operational status for shipping companies and customers; (c) timely online reports and statistics on vessel traffic indicators to aid decision makers and stakeholders; (d) improved payment facilities, including e-payment, and accurate billing calculations; and (e) enhanced communication with shipping agents through electronic links.

Smooth marine services are vital to the efficient functioning of a port. Benefits derived from using ICT in the management and planning, as well as in communication among port community members, include better utilization of tugboats through applying planning modules, increased vessel traffic safety by applying port rules for the use of tugboats and enhanced communication through electronic links.

Land access and intermodal connections are identified as major bottlenecks in many ports, leading to long waiting times for vehicles on access roads. Proposed solutions involve a combination of providing additional infrastructure, for example pre-gate areas or dry ports located near the port parameters; and implementing ICT, allowing for better planning and faster operations. ICT tools able to track cargo and vehicles before and after entering the port area include automatic vehicle location, radio frequency identification and optical character recognition.

By using gate control systems, the following benefits will be derived: (a) increased vehicle and cargo throughput; (b) shortened vehicle waiting and turnaround time; (c) reduced staff requirement for data capture; (d) improved cargo, yard and warehouse dispatch; (e) more reliable container damage inspection; (f) reduced congestion on port roads; and (g) improved port security.

ICT is most frequently applied in the management and operation of cargo terminals. Automated systems are mainly used in container terminal management, but less often implemented in the management and operation of non-containerized cargo terminals.

Applying ICT in cargo terminal management will result in the following benefits:

(a) Enhanced vessel discharge and loading through using planning applications according to vessel stability and crane availability modules;

(b) Enhanced yard utilization through using planning applications according to predefined terminal parameters;

(c) Increased operational efficiency through reduced data entry;

(d) Improved inventory control through electronic registration of cargo movement;

(e) Higher labour efficiency;

(f) Increased efficiency of container handling equipment based on optimal route and pooling;

(g) Increased crane efficiency based on automatic control of work orders;

(h) Accurate information on discharge and loading operations;

(i) Accurate billing calculations and efficient e-payment facilities;

(j) Improved traffic flow inside terminals through control of vehicle and equipment movement;

(k) Improved customer service through updated cargo status and location reports.

Applying ICT in document exchange implies using EDI to transfer documents between different port community members, thus improving trade facilitation. Applying electronic message exchange concepts will increase clerical efficiency and productivity, lower costs and reduce errors through eliminating manual re-keying of data; increase data transfer speed, as electronic means are more immediate than the postal and other manual systems; and improve access to the global marketplace.

A. ICT PORT SYSTEMS

Major ports worldwide are applying ICT community systems, and such applications are increasingly also being introduced in management and operation of medium-sized and smaller ports.

In the transport sector, including port operation management, three different approaches are usually suggested for the application of EDI information systems, namely, central database or port operating system, message exchange broker system and combined system.

1. *Central database/port operating system*

The central database or port operating system allows the port authority to take the leading role in the development and implementation of an EDI community by providing computer capacity, operating capabilities and know-how to facilitate the message transfer, processing and distribution for all cargo- and transport-related information. With a port operating system, all port-related messages are handled efficiently, while those functions not directly involved in the actual port activities, including payment of customs duties for cargo clearance, cannot be as easily achieved.

Centralized systems are usually established in EDI communities where one party is already well equipped with computer and communication facilities and acts as the dominating partner. Development of most port community information systems with centralized databases was started in the early 1980s, when technology was less advanced. They usually operate on mainframe computers, with most users connected online through remote terminals on leased or dial-up lines to key in their information. Participants commit to a complex chain of procedures in which each party contributes to the extensive enlargement of data, and all information processing is managed by one shared system.

The system lacks flexibility when it comes to extending or adapting services, and redundant data entry leads to unwanted enlargement of databases, which cannot be avoided. In general, the port operating system is used in older and more established operations where the port authorities hold strong positions, for example at the ports of Felixstowe, the United Kingdom of Great Britain and Northern Ireland, and Damietta, Egypt.

The operations of a central database or port operating system can be summarized as follows:

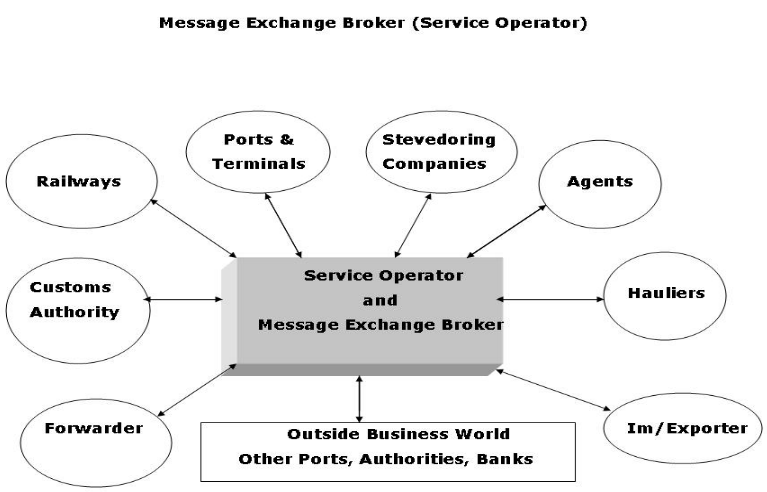
(a) The port authority is leading the development and implementation of an EDI community;

(b) All information, including vessel, cargo and transport operations, is managed by a single, shared database with which all parties communicate; hence, all members of the port community must operate within that system.

2. *Message exchange broker system*

A new company has to be established, usually financed through shares from participating port community members. Unless ICT capacities are out-sourced, investment is required for the provision of communication infrastructure, computer hardware and software and network installation, as well as office rent, staff recruitment and training. Once the company is up and running, operational expenses must be met and investment made for application development. The company provides computer capacity and operating facilities to maintain full EDI services to all port community members for distribution, conversion and validation of messages and mail. Figure 1 illustrates the major participants, or shareholders.

Figure 1. Message exchange broker

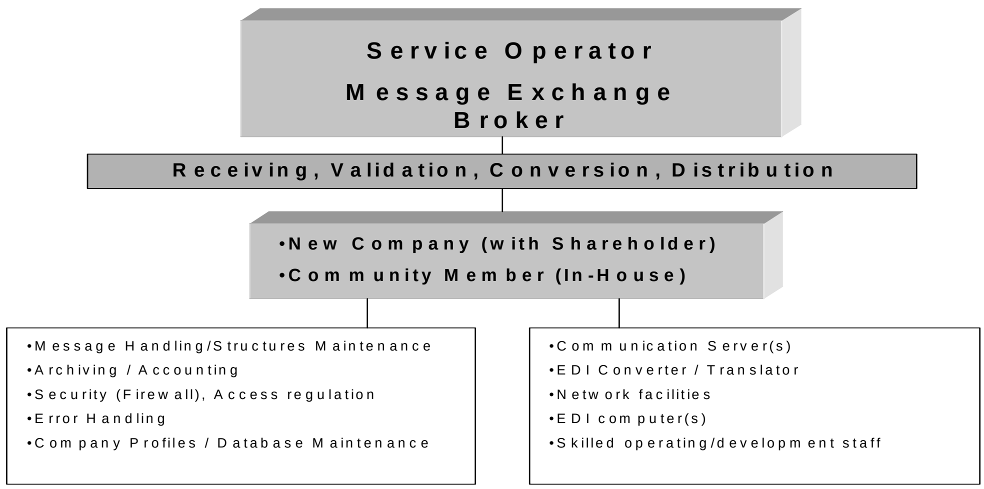


Source: Project of Restructuring the Egyptian Ports: The Second Report (Ministry of Transport, Egypt, June 2001).

The message exchange service operator provides computer capacity and services, maintains databases and acts as an EDI clearance centre for the enrichment and distribution of messages. With additional services and online facilities, for example advanced e-mail options, e-commerce and shared databases for dangerous goods, the message exchange broker system can ensure that a high volume of transactions are processed efficiently through synchronised transport and information chains. Figure 2 illustrated the main functions of such a system.

Each participant operates a separate information system and database to process information on location, using e-mail messages exchanged over the Internet for communication in such standardized structures as the United Nations Directories for Electronic Data Interchange for Administration, Commerce and Transport (EDIFACT). The Internet is regarded as the optimum solution for the development of a multipartner EDI; with the electronic mailbox for sending and receiving messages securely, and acting as a buffer between sender and receiver to protect the system from unauthorised access.

Figure 2. Message exchange broker functions



Source: Project of Restructuring the Egyptian Ports: The Second Report (Ministry of Transport, Egypt, June 2001).

The most common features of the message exchange broker system are the following:

(a) A central communication server handling the process of incoming and outgoing EDI information by using a mailbox system;

(b) Basic standards for communication protocols, networks and hardware platforms for national and international connections;

(c) Internet communication and facilities for database inquiries;

(d) Technical support, system back-up and EDI software and translation services to and from the agreed standard.

The Port of Rotterdam, the Netherlands, uses a module whereby partner systems can remain independent and a mailbox service ensuring all port community members are able to communicate with each other.

The operations of a message exchange broker system can be summarized as follows:

(a) A new company is established, financed through shares from participating port community members;

(b) The company provides computer capacity and operating facilities;

(c) Each member operates an independent information system, using e-mail or value added networks for communication.

3. *Combined system*

The combined system incorporates the purely EDI service of message handling and value added network possibilities with a shared database to store information of mutual interest for all port community members, for example databases on dangerous goods and vessel registration.

Most modern port EDI communities are based on combined systems for major users, and offering online facilities for smaller users without electronic data processing. Many port authorities started with a multipartner EDI or message exchange broker with limited services, subsequently extending and upgrading the system. Examples include the port operations at Marseille and Le Havre in France, Hamburg in Germany and Alexandria in Egypt.

The operations of a combined system can be summarized as follows:

(a) The use of EDI services for message handling, in combination with a shared database for storing information of mutual interest to all port community members.

4. *Comparison*

Design and management of an EDI community system is often done at the central level, at least initially, with the choice of approach influenced by the characteristics of the port community members and other participants and users. In general, central database or port operating modules are used in earlier port systems and in port operations where the position of the port authority is strong; whilst the pure EDI and message exchange broker systems are favoured at ports where individual members of the port community are already automated, or where private enterprises operating in ports and terminals have strong roles. In practice, most systems implemented in port operation management are a mixture of approaches. Some systems are adapted to accommodate automated users who do not wish to give their information to a central database, preferring to use EDI to send data through the central value added network system to other members of the port community. The EDI community systems often provide extended services to cover central applications, including track and tracing and databases for dangerous goods and vessel registration.

A comparison of the three ICT port systems is presented in table 1.

TABLE 1. COMPARISON OF ICT PORT SYSTEMS

System	Advantages	Disadvantages
Central database/Port operating system	• The port determines the priorities • All information can be accessed from one centralized database	• The port is responsible for the whole operational process • The system lacks flexibility • All port community members must be part of the chain • There is extensive data enlargement through duplication of data entry

TABLE 1. (*continued*)

System	Advantages	Disadvantages
Message exchange broker	• Port community members operate their own information systems • The operational process and technical services are handled by a specialized entity	• Individual companies require their own databases to benefit from the environment • There is no shared information between different entities • All port community members are required to invest in the system
Combined system	• Partners are free either to operate their own Internet solution, or to share the centralized database • Operational and technical services are handled by a specialized entity	• All port community members are required to invest in the system.

Source: Project of Restructuring the Egyptian Ports: The Second Report (Ministry of Transport, Egypt, June 2001).

B. APPLICATION SOFTWARE SERVICES

Effective port and terminal management requires up-to-date information about the various interrelated operational and administrative aspects of the entire port community. The objective of the main applications and their respective modules, as well as auxiliary services provided by additional ICT tools and facilities, is to provide information and data for effective management and decision support.

1. *Port and terminal operating management*

(a) *Berth planning and scheduling module*

Berth planning enables the port to plan and manage incoming vessels according to predefined port rules and regulations. The plan is built on mooring requests from shipping agents, including main voyage information, while the port simulator module is a graphical tool creating a schedule with sequenced queues for each quay crane.

(b) *Vessel planning and control module*

The vessel planning and control module provides tools to visually create, plan, view and check vessel stowage, as well as providing detailed graphical representations of specific vessels. The module calculates lashing, stress, stability and segregation of dangerous goods. Additional options provide detailed reefer monitoring and full EDI support for stow plan information.

(c) *Yard planning and control module*

The yard planning and control module provides complete control of any yard situation, from a low-volume loading and discharging site to a high-density trans-shipment operation using all types of container handling equipment. The module can automatically allocate yard space and assign container position, in addition to being a decision support tool, resulting in better yard management and maximum use of equipment, labour and yard space. A yard inventory can be maintained by linking to a container position detection system using global positioning technology.

(d) *Equipment control module*

With the equipment control module, staff can direct container movement at the terminal, assign equipment pools to points of work, set up queues to container handling equipment and enable radio data terminal operators to send work instructions to equipment operators. The module also validates various lifting constraints, considering such factors as equipment type, stacking capability and container type that can be handled with safe working load. In addition to providing detailed reporting on equipment statistics, the module automatically assigns, dispatches and controls work at the terminal, and optimizes the use of straddle carriers.

(e) *Gate control module*

Wireless gate control modules automate various operations needed to control and trace movements of vehicles entering and leaving the port area, checking reservations and registering weights. The vehicle booking module is used to capture all vehicle, driver and cargo data before arrival at gate to speed up entry procedures and preventing bottlenecks. The entry control module prevents vehicles from entering before all required cargo procedures have been completed. The system then issues a printed routing ticket identifying the cargo location, thus facilitating traffic inside the port area and preventing congestion. The exit control module checks cargo-related parameters, preventing vehicles from leaving the port before all financial or procedural issues have been completed. The module integrates weight data into the system, calculates excess weight and issues the invoice. As vehicle entry and exit times are recorded, the elapsed time is calculated for the stay within the port area and an invoice is issued.

(f) *Rail planning and control module*

The rail planning and control module is applicable for terminals with on-dock or inland rail facilities. Using electronic data, the module defines the train consist, indicates the track position of each car on the screen, creates load and discharge plans and validates those plans against detailed route restrictions and car constraints. Through integrating all terminal activity, the module can also plan container transfer directly to trains from the gate, yard and vessel, or vice versa.

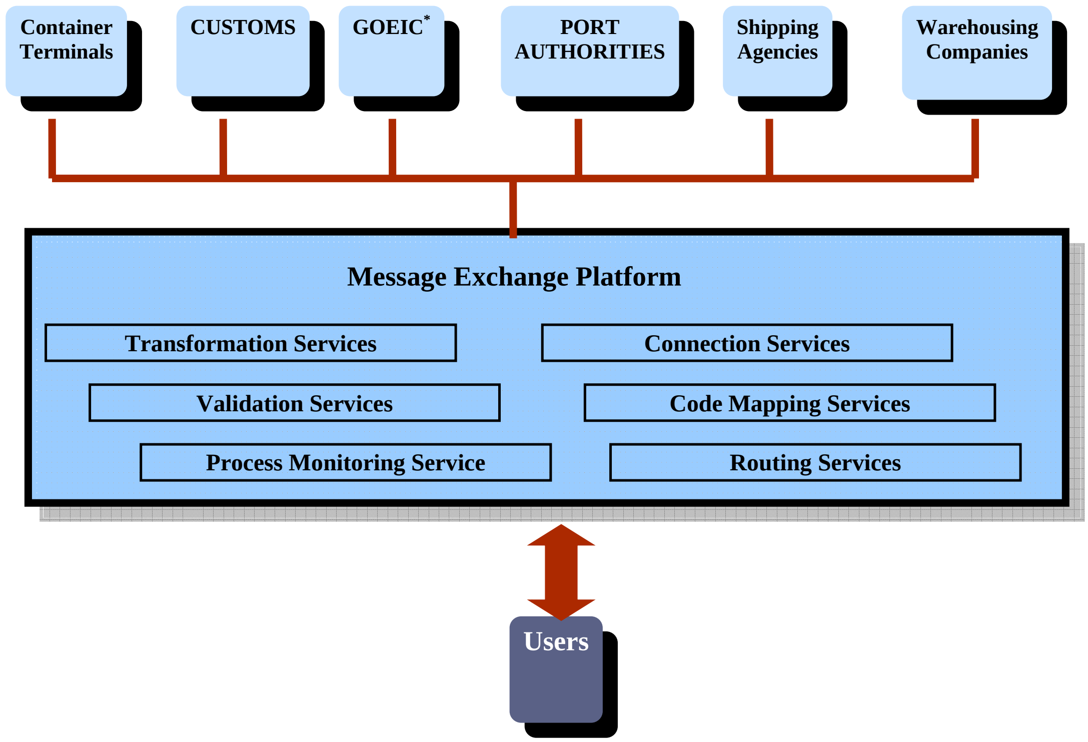
(g) *Billing module*

The billing module automates the various invoice types issued by the port authority and other members of the port community. Vessel and cargo operation services to be invoiced include agency, stevedoring, direct handling, storage and warehousing. Container terminal services to be invoiced include less than container load, load and discharge, and shift and storage charges. The module should have the flexibility to accommodate additional invoice types and modify predefined ones, for example according to tax regulations or applied discounts. In addition, service timings, financial year and shift periods need to be respected in calculations.

2. *Message exchange broker services*

Message exchange broker services are provided either directly by the clearing centre, or by a subcontractor who reports to the main clearing centre. Figure 3 illustrates the services provided through the message exchange platform.

Figure 3. Message exchange broker services



Source: *Project of Restructuring the Egyptian Ports*: *The First Report* (Ministry of Transport, Egypt, February 2001).

* General Organization for Exports and Imports Control, Ministry of Trade and Industry, Egypt.

(a) *Message translation and routing*

Message-handling includes the following services: (i) translation and transformation from one format or standard to another; (ii) routing to manage the flow of messages between port community members; (iii) queuing to enable asynchronous communication between port community members and their applications; (iv) data integration through data access gateways; (v) digital signature certificate and audit trail services; and (vi) security and confidentiality, including encryption.

(b) *Workflow process and management*

The process management system, directed by a committee representing the major port community members, maintains an efficient and competitive workflow by managing the flow and state of messages between automated processes. Managing business transactions independently includes monitoring the workflow within the transport process, streamlining business procedures whenever necessary and re-engineering the business process, namely, adding new processes to improve performance or deleting repetitive procedures causing delays.

(c) *Data warehousing and provision of business intelligence tools*

Through connecting the workflow management system and the messaging function, business intelligence tools can be added to analyse business events and identify trends and patterns, including monitoring service levels and response times. Data is extracted from the workflow system database, then filtered and loaded into a dedicated data warehouse for evaluation through online analytical processing and data mining to refine, improve and implement the business processes. Data mining can also be provided to individual port community members or trading communities requiring business transaction data for information and analysis.

(d) *Document standardization*

By providing a set of shared standards applied multilaterally, the message exchange broker provides document standardization tasks to eliminate bilateral data interchange agreements for structure and content of electronic data being exchanged between two port community members.

(e) *Application integration and customization*

The message exchange broker provides value added service application integration tasks customized according to the legacy system of each port community member. The objective is to help members to turn their in-house applications into an EDI-enabled application, and to integrate exchanged data into their existing databases.

3. *Portal services*

Portal services provide port community members with access to services through the Internet. The system enables end-to-end e-transaction, from the booking of a service to the point of billing. Services include berth, stevedoring and crane bookings; the ordering of pilotage and tugboats; electronic quay plans for container loading and discharge; and pre-gate services. Furthermore, electronic delivery, government permit applications and data on vessel itinerary, container handling status, cargo status and dangerous goods declaration can be provided.

C. INFRASTRUCTURE

Successful ICT application in port operations begins with a thorough and precise study of the infrastructure needs, which are determined according to type and scope of the specific ICT system to be applied. Detailed below are the basic infrastructure preparations required for the implementation of ICT in the management and operation of seaports.

1. *Civil infrastructure*

(a) *Premises*

Customs and agency offices, control centres, police station and other existing buildings and their location within the port area should be evaluated in order to accelerate and facilitate procedures for port users. Additional structures may need to be constructed to accommodate port automation and electronic administration, as well as the actual electronic systems for terminals and quays and the wireless grid.

(b) *Gates*

The gates and their location should be studied in order to achieve the best possible traffic flow inside and outside the port area, and also to determine the specific tasks performed at the different gates depending on type of activity and location. Furthermore, gates should be provided with automatic control rooms and barrier arms to control vehicle entry and exit.

(c) *Roads*

External and connecting roads leading to the main road network outside the port area need to be studied to ensure the port entry and exit routes are easily accessible and that there are parking facilities adjacent to the port entry points. Within the port area, road routes should be studied and planned in a way that covers the movement inside the port perimeters. Some roads may need to be designated for traffic related to the specific activity of certain quays. It may be advisable to use curb stones for compulsory directions, display information boards to indicate locations and provide all roads with sufficient lighting to enable control cameras to monitor the area round the clock.

(d) *Yards*

A plan should be proposed and applied according to the expected quay activity. Adequate yards should be provided for each type of activity and planned according to the maximum storage capacity required.

(e) *Equipment*

The number of weighbridges to be used for loading and dispatch should be studied and planned to avoid vehicle congestion, taking into consideration such factors as proximity to parking areas. The survey should also indicate the number and type of quay cranes required according to shipment.

2. *Security and safety infrastructure*

(a) *Networked video surveillance*

Surveillance, including the use of digital video to monitor perimeters, access points and public spaces, is of priority to a seaport. By introducing a common communications infrastructure, ports can utilize network-enabled video in place of closed-circuit television systems for remote and mobile monitoring and recording and event reconstruction.

(b) *Container security*

While a conventional seal comprises of a bolt that mechanically prevents the container from being opened, an electronic seal, verifiable through radio frequency identification scanning, can include information for identification, registration and continuous monitoring. Container security systems can be further enhanced by embedded sensors, including door light sensors, gamma ray detectors and chemical sensors, which monitor tampering, theft and placement of proscribed freight. Such electronic security systems can significantly improve container security; however, since they demand flexible cooperation, interaction with the outside world must itself be secure.

(c) *Access control*

An ICT-based access control system comprises security checkpoints at entrance portals, which are in networked communication with a central processor. A database is also connected to the processor, either on site or at a central location, and is accessible from port community members, as well as from other ports. Checkpoints can include a smart card or magnetic stripe reader, biometric devices and optical scanners. A registration module connected to the central processor is used to issue credentials for persons requiring access, and also to store identifier data in the database. The registration module includes a camera for capturing a digital image of persons seeking entry, and an application for inputting alphanumeric data to retrieve coded electronic data from identification documents and obtaining a biometric reference. The information forms unique identifier data for each person, which is stored in the database.

3. *Operational infrastructure*

Central communications lines and facilities of the surrounding area should be studied and alternative suggestions should be defined to attain optimum performance. Fibre-optic network and routes should be assessed and the most appropriate locations for inspection rooms specified in order to connect the electronic administration building with premises for customs and control, with vehicle weighbridges and with entry and exit gates.

The port should be provided with servers for hosting port operation applications, for example the UNIX operating system or Microsoft Windows, according to operational needs. Servers should have large storage capacities, be equipped with a tape library and be available via the network, including storage area network with duality and redundancy to prevent single point of failure situations.

In addition, the port administration should be provided with personal computers, storage and backup systems and firewall hardware to protect the internal network and the servers from security system breaches, possibly with a prepaid card system for access, as well as a touch screen security system.

II. PORT SOLUTIONS AND APPLICATION PACKAGES

Most systems used in port operation and management are customized for container terminal operation. They differ to some degree from port operating systems, which integrate the whole port community and all its members. There are a number of terminal operating systems on the market; this chapter presents an introduction to some of the best known and most used applications and modules.

A. TERMINAL OPERATING SYSTEMS AND PACKAGES

1. *Navis SPARCS/Navis Express*[1]

Navis LLC is the most well known port solution provider, with terminal operating systems implemented at over 175 terminals worldwide. Among the range of applications, Navis Synchronous Planning and Real-time Control System (SPARCS) and Navis Express are two of the most widely used terminal operating systems. Navis SPARCS automates and optimizes vessel and rail planning, yard allocation and equipment dispatch, integrating the entire terminal operation. The system operates in real-time, tracking crane handling equipment and activity, as well as dispatching work orders to radio data terminals. Navis Express manages and maintains terminal business transactions and data processing, recording and invoicing transactions and services. By automating booking, billing, data exchange and reporting functions, all transactions and work are captured, enabling the port community members to track performance, improve customer service and increase profitability.

2. *Cosmos*[2]

Cosmos provides the second most applied terminal operating system packages worldwide, with solutions implemented at over a hundred terminals at such ports as Antwerp in Belgium and Le Havre in France. A wide range of software applications and modules are available: SHIPS and SPACE handle vessel and yard planning, respectively, and TRAFIC is a container application for equipment control. The backbone of the Cosmos software package is CTCS Container Terminal Control System, a host application available in several languages which supports and controls all administrative and terminal activities. Applications for specific services include BAS Berth Allocation System, GOS Gate Operating System and COREBIS Contract Registration and Billing System.

3. *CATOS*[3]

CATOS Computer Automated Terminal Operation System combines terminal management applications and Internet-based technology for graphical interfaces for vessel and yard planning. Developed by Embarcadero Systems Corporation (ESC) and Total Soft Bank (TSB) of the Republic of Korea, CATOS also provides external and internal communications tools and modules which can be applied to streamline marine operation and management through web service, EDI communications and radio frequency techniques. Examples include YT Pooling, which issues automatic dispatch orders to yard tractors based on job status and location; and Random Grounding for yard use and container stacking.

4. *CITOS*[4]

CITOS Computer Integrated Terminal Operations System was first developed in 1988 by the Port Singapore Authority (PSA), and is the operating system at the Port of Singapore, one of the world's leading

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[1] A complete listing of Navis systems and modules is available at: http://www.navis.com.

[2] A complete listing of Cosmos systems and modules is available at: http://www.cosmosworldwide.com.

[3] A complete listing of CATOS systems and modules is available at: http://www.tsb.co.kr/eng/02_solution/catos.asp.

[4] A complete listing of CITOS systems and modules is available at: http://www.portnet.com/03products/citos.htm.

container trans-shipment hubs. PSA Corporation Limited subsidiary Portnet.com has developed CITOS modules for various aspects of port operation and management, including terminal planning, covering berth allocation and vessel, yard and rail planning; terminal operations, covering computer-aided and real-time operations, control centres and gate operations; equipment maintenance; and invoicing and performance reporting for analysis and strategic planning.

5. *Genoa Breakbulk Management System*[5]

The non-containerized terminal operating system Genoa was developed by Tideworks Technology, which also provides solutions for container terminal operation and vessel, yard and rail planning. Genoa Terminal manages vessel and terminal functions for different cargo types, and includes a module for the handling of containers at multi-purpose terminals; however, for large or dedicated container terminals, Mainsail Terminal Management System is the preferred solution. Other modules include Genoa Storage, which provides warehouse management, and Genoa CFS, which integrates such container freight station activities as stripping and stuffing of containers with warehousing and terminal functions. In addition, tools for providing communications links and online access are available.

6. *CTIS*[6]

CTIS Container Terminal Information System was developed by Hamburg Port Consulting based on projects for the parent company HHLA Hamburg Port and Warehouse Corporation, Germany. Modules include gate- and vessel monitoring; vessel, berth, yard and stowage planning; and customs access, EDI and report generator. The gate module administers paperless pre-arrivals through EDI booking or customer online access. For stowage planning with graphical interface, CTIS is connected to STOWMAN, developed by Seacos, INTERSCHALT maritime systems AG. Invoicing is provided through CuBiS Customer Billing System, and pre-defined graphic reports and statistics are delivered by a report generator.

7. *MACH*[7]

MACH Marine Container Handling system, developed by CMC Limited, is an integrated, modular container terminal management system, implemented at the British port of Felixstowe and the EUROGATE Container Terminal at the German port of Bremerhaven. MACH comprises planning, operation and container freight station systems, and modules for vessel, berth and yard planning; container administration, including recording of data on loading and discharge, gate and inter-terminal transfer; and marine operations. Additional functions, including operation control and monitoring and operation resource management, are handled by MACH.OCM and MACH.ORM, respectively. MACH also provides modules covering invoicing and administration.

B. Overview of ICT solutions at selected ports

1. *Selected international ports*

ICT community systems have been developed and implemented at major ports worldwide. Table 2 provides a schematic overview of various port solutions at selected international ports.

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[5] A complete listing of Genoa systems and modules is available at: http://www.tideworks.com/eng/products/genoa/index html.

[6] A complete listing of CTIS systems and modules is available at: http://www.hamburgportconsulting.de/index.php?option =com_content&task=view&id=15&Itemid=18.

[7] A complete listing of MACH systems and modules is available at: http://www.cmcltd.com/industry_practices/shipping /mach.htm.

TABLE 2. OVERVIEW OF ICT SOLUTIONS AT SELECTED INTERNATIONAL PORTS

Port	Model/ concept	Year of implementation	Capital shareholder	Structure	Terminal operating system	Message exchange company	Number of users
Antwerp, Belgium	message exchange broker	1986	Chamber of Commerce and Industry of Antwerp; local transport associates	cooperative partnership	Cosmos CTCS	Seagha	>250
Marseille, France	combined system	1987	Chamber of Commerce and Industry Marseille-Provence; freight forwarders and agents Subsequently: Port of Marseille Authority; Marseille Gyptis International (both systems)	limited company	CATOS (TSB)	Protis (vessel-oriented) Escale (goods-oriented)	200 (400 terminals) 50 (150 terminals)
Le Havre, France	combined system	1983	customs and forwarding agents Subsequently: SOGET (owned by professional associations)	limited company	Cosmos CTCS	ADEMAR PROTIS+	250 (460 terminals)
Bremen/Bremerhaven, Germany	central database	1973	forwarders (42%); agents (11%); port operators (38%); stevedores (9%)	Limited company (GmbH)		Compass/ Lotse	-(1,000 terminals)
Hamburg, Germany	combined system	1982	Hamburg Port Authority: port companies Subsequently: forwarders (30%); terminal operators (30%); agents (30%); control firm (10%) with representation on DAKOSY supervisory Board	limited company (GmbH)	CTIS HPC	DAKOSY	>200

TABLE 2. (*continued*)

Port	Model/ concept	Year of implementation	Capital shareholder	Structure	Terminal operating system	Message exchange company	Number of users
Genoa, Italy	central database	1990	Genoa Port Authority; Sistimi e Telematica (SeT)	limited company (S.p.A.)	Genoa Terminal; Tideworks Technology	SeT Freight, SeT Ship, SeT Cont, SeT Sim	N/A
Busan, Korea (Republic of)	combined system	1991	KL-Net staff (13.01%) associations (2.83%) logistics industry (47.4%) Busan Container Terminal Operation Corporation (35.2%) DACOM and others (1.56%)	limited company		KL-Net	N/A
Port Louis, Mauritius		1994	State-related organizations (51%): Mauritius Telecom, Mauritius Ports Authority and Cargo Handling Corporation; Private sector investors: Mauritius Chamber of Commerce and Industry, Singapore Network Services			TradeNet	
Rotterdam, Netherlands (the)	message exchange broker	1983-87	INTIS; Port of Rotterdam Authority; association of private companies; KNP Royal Dutch Telecom; 30 individual companies *Subsequently:* PTT Telecom Holland; Capgemini (formerly Cap Volmac) own majority	limited company (B.V.)	Port infolink	INTISFACE	>200

TABLE 2. (*continued*)

Port	Model/ concept	Year of implementation	Capital shareholder	Structure	Terminal operating system	Message exchange company	Number of users
Singapore		1984	PSA Corporation Ltd.	limited company	CITOS	PORTNET	N/A
Felixstowe, United Kingdom	central database	1980	On cooperative basis: stevedoring companies; agents; freight forwarder; hauliers	public limited company (plc)	MACH; CMC	FCP80/FCPS	475

Source: Maritime Research and Consultation Center and HPC Hamburg Port Consulting, *Project of Restructuring the Egyptian Ports*: *The Third Report*, (Ministry of Transport, Egypt, February 2002).

The following section provides a short description of the ICT systems and applications implemented at the ports listed in table 2. The focus is on the organizational structure and type of information exchanged at each port, the members of the port community and their experience during implementation, and future plans and development.

(a) *Port of Antwerp*

At the Port of Antwerp, Belgium, such activities as cargo handling are operated by private enterprises. For the port to remain competitive, an information system was regarded essential and, in 1986, Seagha was founded to set up pure EDI message services between members of the port community. The application was developed into a full service system before being introduced on a commercial basis. Port community members and their customers were initially slow to respond, mainly because of scepticism from the many smaller companies operating within the port. It had been the intention of Seagha to supply EDI services to those smaller companies; in practice, however, larger companies, numbering over one hundred, are the main users. Partnership is open to all port community members and related transport companies.

Seagha does not use the national network for message and data exchange, but operates its own network. Messages transferred cover some 40 EDIFACT standards for handling container, freight and vessel movement, as well as customs declarations. The total number of messages is increasing continuously, especially in the rapidly expanding area of dangerous goods. Communications links with the systems of the Belgian Customs Authority, Belgian Railways, Brussels Airport and other port authorities have been set up.

(b) *Port of Marseille*

At the Port of Marseille, France, the development of a port information system was initiated by the Chamber of Commerce and Industry of Marseille-Provence, in cooperation with port community members. Marseille Gyptis International was established to develop a cargo management system and, with the subsequent takeover by the Port of Marseille Authority, also developed a system for vessel management.

With over 250 users, the two systems operate on a central database platform and handle cargo bookings, bills of lading and customs and dangerous goods declarations, as well as the monitoring of quay operations. Data input and output are offered through EDI, using EDIFACT standards. Future plans include extending EDI solutions to other Mediterranean ports and interconnections to non-European ports.

(c) *Port of Le Havre*

In 1983, on the suggestion from the French Customs and Excise Service, a computerized freight handling system, originally developed for air freight, was expanded and implemented into the management operation of the Port of Le Havre, France. The Customs Computer Network (SOFI) did not cover such port operations as transit, trans-shipment and break bulk. The success of the system and the need for extension of its functions led operators and the port authority to enrich it through ADEMAR PROTIS+ Automated Customs Clearance of Goods. The running of the system is out-sourced to SOGET, a company formed especially for that purpose by members of the port community.

ADEMAR PROTIS+ facilitates exchanges of information and documents between the operators at Le Havre and an interoperable network of around 250 members. With some 260 terminals and 200 teleprinters, the total network is interfaced with SOFI, the vessel traffic management system and the container database; and by EDI with the data processing systems of the Compagnie Générale Maritime and four container terminal operators. Future plans include establishing additional connections to European ports, especially for the exchanging of dangerous goods information; vessel status, arrival and departure times; and cargo and container data exchanged in the EDIFACT format.

(d) *Ports of Bremen and Bremerhaven*

Already in the early 1970s, the Ports of Bremen and Bremerhaven, Germany, started designing and implementing a port information system. A limited company was formed for that purpose, with participation and funding from forwarding and shipping agents, port operators, stevedoring companies and cargo controllers, and with an initial investment from the German Government. The company is open to all involved in cargo handling at any of the ports connected to the system, including railways, road hauliers, customs and port authorities.

Initially, the information exchanged was data regarding shipment, bills of lading and cargo manifests. Subsequently, a full service system was developed, covering all relevant types of information and organized through a conglomerate of related sub-systems under the name of Compass/Lotse. The environment made it necessary to base the system on a central solution; however, as the operation deals with competing companies within the system, security and confidentiality are of high priority. Development is ongoing and the functionality of the system is being improved.

(e) *Port of Hamburg*

DAKOSY was established in 1982 by the Hamburg Port Authority and private enterprises, including freight forwarders and agents, to set up a port information system. After a successful start, shares were acquired by the main user groups, namely, freight forwarders, terminal operators, liner agents and control firms, who are all represented on the board of the company.

The backbone of DAKOSY is an EDI communications system able to transfer messages independent of hardware type. It covers the handling of customs declarations, consignment data and information from Die Bahn, the German railways. Unlike at other ports, users initially rejected central database systems, as many had already implemented mainframe solutions; however, the advantage of having central databases on certain vital information, including sailing lists and dangerous goods, was judged as positive. As EDIFACT had not yet been developed at the time of start-up, the company designed its own standards, but is now in the process of converting into full EDIFACT standards. Future developments are expected to aim towards further integration with other port systems, focussing on intelligent technology for container terminal and port communication.

(f) *Port of Genoa*

The Port of Genoa, Italy, is the gateway to the northern industrial centres of Milan and Turin. A dedicated company, Sistemi e Telematica (SeT), was established to develop an information system and related exchange facilities based on a central database. Input is mainly via terminals, but can also be through EDI. The users are all involved in cargo handling, which is mainly container-based but also includes other types of freight. The system can be accessed from terminals and from stand-alone personal computers and covers cargo and customs manifests, container tracking and bills of lading. The port is participating in the establishment of an EDI network connecting other Mediterranean ports.

(g) *Port of Busan*

The Ministry of Maritime Affairs and Fisheries of the Republic of Korea built a back-to-back frame information network in 1984 to introduce a paperless administration and provide integrated port service for handling imports and exports at the Port of Busan. In 1992, Port-MIS Management Information System was applied for online service, subsequently expanding to such other ports as Ulsan, Masan and Incheon. By 1997, all major ports were linked to the Port-MIS network on the EDI platform KL-Net; and by 1999, a nationwide network and integrated database were in place.

(h) *Port Louis*

EDI technology was implemented at Port Louis, Mauritius, in 1994. A trade documentation processing system, TradeNet, was modeled on a similar solution for processing customs declarations applied at the Port of Singapore. A value added network operator was required, and a joint venture company involving public and private sector representatives and foreign technical partners was set up for that purpose. The Mauritius Network Services has 51 per cent state-related shareholders, inlcuding the Mauritius Ports Authority, Mauritius Telecom and the Cargo Handling Corporation Limited, and two private-sector investors, namely, the Mauritius Chamber of Commerce and Industry and Singapore Network Services.

In addition to enabling online customs transactions, the system facilitates data exchange for such port community members as freight stations, free zones and warehousing companies, accepting bills of entry as the only legal electronic document for release or shipment of cargo and containers. Customer services include online information on vessel, berth and equipment allocation, and status of loading and discharge of cargo.

(i) *Port of Rotterdam*

The Port of Rotterdam, the Netherlands, is the largest in the world. In the mid-1980s, a decision was taken to develop a port information system. The approach differed from those taken by many other port authorities as a result of having to incorporate the large number of existing, widespread activities and advanced technological systems of the many transport companies within the port community. The task was to design a system where users could remain independent, while at the same time interacting with each other. Therefore, a pure EDI message system was chosen. The International Transport Information System (INTIS) was set up with funding from the City of Rotterdam, the German Government, private enterprises operating within the port, telecommunications companies and up to 30 individual organizations, including agents, freight forwarders and shipping companies.

INTIS builds heavily on the use of EDIFACT standard messages and has developed numerous additional standards within that frame to cover shipping instructions, customs declarations and container movements on sea and on land. The start-up period was difficult, with a multitude of problems and high costs; however, a sharp increase in the number of users occurred when a customs declaration module was introduced. There are some 200 users, though very few shippers use the system. Port infolink is a port-wide platform coordinating all information and communications services. It enables every member of the port community to efficiently exchange information with each other. INTIS uses the client/server method, which handles all tasks, from tailoring solutions to existing format, to installing equipment.

(j) *Port of Singapore*

The Port Singapore Authority set up PORTNET in 1984. With improvements over the years, the system provides integrated services to shipping companies, hauliers, freight forwarders, shippers and local government agencies operating at the Port of Singapore. In keeping with technological advances, the system was moved onto the Internet platform in June 1999, thereby connecting it to the global shipping and port community.

(k) *Port of Felixstowe*

The Port of Felixstowe, the United Kingdom of Great Britain and Northern Ireland, has developed from a relatively small port to the largest container port in the country. Part of the reason for such development is the design and implementation of the FCP80 port information system in the 1980s. The system builds on a central database where all vessel, cargo and customs data are registered and updated, with value added services including the handling of customs clearance procedures.

The automation project was set up by representatives of major port community members on a cooperative basis, with no dominant party. A public limited company was subsequently formed to handle operations and development, though all major decisions must be taken unanimously by the board of directors. As the system is primarily intended for port management with all parties operating at the port partaking, very few shippers are connected.

Initially, private exchange formats were used, but the implementation of EDIFACT standards is in progress. At first, the system exchanged information on the import side of transport operations only, focusing on customs clearance procedures, with clearance time reduced from three days to six hours. Subsequently, the system has been expanded to include cargo inventory control, which has brought the average clearance time down to two hours. The functionality includes transport order, vessel and consignment details, manifest, and dangerous goods and customs clearance. FCP80, renamed the Felixstowe Cargo Processing System (FCPS), has been implemented at other major British ports, and it is being expanded to service areas of export control and dangerous goods handling.

2. *Selected ESCWA ports*

(a) *Damietta Port, Egypt*

Since 2005, Damietta Port Authority is using Navis SPARCS and Express for vessel, cargo and container planning and operation. The hardware and networks were provided by the port authority, with the Ministry of Communications and Information Technology acting as consultant. Operations are outsourced to Integrated Solutions for Ports (ISFP) to ensure availability and reliability.

(b) *Aqaba Port, Jordan*

The terminal operating system implemented by the Aqaba Ports Corporation was developed by Delta Computers, a Jordanian software company. It is a complete package that incorporates vessel and cargo movement, invoicing, statistical reports and customer services.

(c) *Port of Beirut, Lebanon*

The Port of Beirut initiated an ICT development plan in 2006, and manifest automation was then introduced. The Beirut Port Information System uses eBiS electronic billing system with CAMA Computer Assisted Mass Appraisals, by Software Techniques, for shipping agents and freight forwarders. The container terminal is managed by a private operator using Navis software solutions, and a tender is being prepared for an automated system for the general cargo terminal.

(d) *Port Sultan Qaboos and Port of Salalah, Oman*

At Port Sultan Qaboos, the first phase of computation was implemented in 1986 by Port Services Corporation (S.A.O.G.), a fully-owned Omani company. The corporation has signed a contract with Total

Soft Bank (TSB) of the Republic of Korea to install a customized version of the CATOS software system, expected to be commissioned by the end of 2007.

At the Port of Salalah, Navis SPARCS has been implemented for yard planning and management to improve productivity, labour and equipment utilization, and integrate yard and vessel planning. Navis Express is used for the handling of data related to terminal transactions, including gate, yard, vessel activity; the import and export process; and booking, billing and work order management.

(e) *Port of Lattakia, Syrian Arab Republic*

In 2004, a contract was signed between Lattakia Port General Company and the Maritime Research and Consultation Center, affiliated to the Arab Academy for Science, Technology and Maritime Transport of Egypt, to provide a comprehensive, real-time port management solution for vessel, cargo and terminal operations and invoicing. The hardware and networks have been provided by the port authority, and the project is awaiting the completion of the contract and the implementation process.

(f) *Dubai Ports, United Arab Emirates*

The two ports in Dubai, Port Rashid and Jebel Ali Port, are managed by DP World, an international marine terminal operator. A container terminal management system, developed by DP World, supports all operations, covering vessel, berth and yard operations, container inventory, equipment management and financial billing. Schedules, statistics and reports are derived from real-time data on the Internet. Management operations are complemented by the Navis SPARCS module for vessel and yard planning, equipment scheduling and dispatch. Graphic tracking displays of container movement and information transmission to mobile data terminals in container handling vehicles rely on global positioning technology.

The container terminal system, Zodiac, is used for vessel and yard planning and equipment control; with SRS Smart Rail System, based on a digital global positioning system, facilitating crane operation, including automatic steering. Both software applications were developed by DP World, as was the CFSS Container Freight Station System, which computerizes container operations from receiving to delivery, including consignment tracking. The system feeds cargo information to the MDS Manifest and Documentation System for clearance.

III. INFORMATION EXCHANGE AMONG PORT STAKEHOLDERS

This chapter defines the documentary circuits that exist among the different port community members in order to specify the administrative processes and reorganize, simplify and automate the selected procedures. It describes the administrative cycles which take place within the port community, focusing on the external documents used by the different agents. The information and documents exchanged between port community members can then be re-engineered in order to avoid bottlenecks and enhance the overall performance. The objective is to guarantee a flow of uninterrupted information to the different entities inside the port in order to ensure the least possible delay in customs clearance of goods.

There is a clear distinction between vessel-related and cargo-related systems. Vessel-related systems contain information concerning such planning data as movement and procedure. They are typical tasks of the port authority when monitoring vessel movement, berth management, towage services and pilotage. Cargo-related systems deal with, inter alia, customs handling, stevedoring, terminal operations, vessel movement and cargo declaration, including dangerous goods. They are mainly used by shippers, forwarders, customs, railways and other ports, and cover bills of lading, manifests, bookings, customs and dangerous goods declarations, and container and wagon handling.

A. PORT COMMUNITY MEMBERS

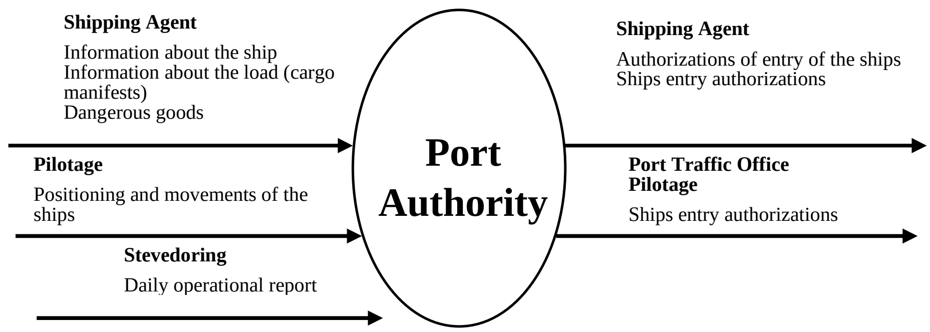
In order to visualize the data transfer relationship and how it corresponds to the physical documentation handled during the various segments of port operation and management, the port community members and their tasks need to be described.

1. *Port authority*

The port authority is the main entity in charge of effective management and operation of the port. The various functions correspond to tasks of control, management and administration of port services, coordination of the activities of the administrative bodies operating within the port, control of planning, construction, marketing of port services, collection of fees and tariffs for services rendered and the granting of concessions, licenses and service contracts within the port.

The port authority enforces procedures for activities within the port by supervising, overseeing and controlling the physical operations of cargo handling and vessel movement. That includes coordinating vessel entry and exit, securing the port premises and the goods within it, inspecting loads and undertaking stowage and dispatch. Regarding goods, there are two types of information flow: one common to all loads that enter the port and associated with the flow of the cargo manifest, and one where different consignments of a load are detailed and dangerous goods specified. Such data are provided by the shipping agent, though the origin of the information is the owner of the goods. Information relating to the vessel is also received by the port authority from the shipping agent, who generates the data pertaining to vessel arrival from information sent by the port of origin or the shipowner. Figure 4 illustrates the interactions with the port authority.

Figure 4. Port authority



Source: Project of Restructuring the Egyptian Ports: The First Report (Ministry of Transport, Egypt, February 2001).

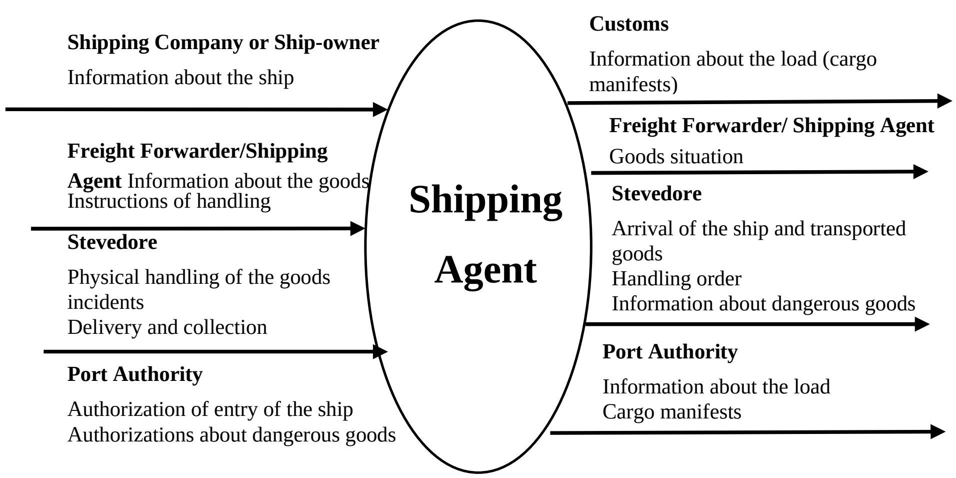
2. *Shipping agent*

The shipping agent acts as an independent intermediary on behalf of the shipping company or the shipowner, and coordinates between the ports of origin and destination. Functions comprise providing services to the vessel and crew, and submitting information relating to length of stay to the port administration. The shipping agent also handles a range of cargo-related tasks, including documentation.

Regarding the data flow, the shipping agent is the main facilitator, receiving data corresponding to both the vessel and the cargo. The data is passed on to other port community members, including port authorities, freight forwarders, stevedores and customs agents, in order for them to undertake their functions. It is vital that the relevant information is sent at the appropriate time in order for each port entity to fulfil its function and facilitate timely execution. It should be noted that the information, including vessel data and a detailed description of the goods, is originally generated by the shipowner and the owner of the goods. The shipping agent at the port of origin receives information about the goods directly from the exporter or the goods consignee, generally the freight forwarder or customs agent.

With regards to data concerning the handling of goods and procedures relating to that activity, the information flow is solely between the shipping agent and the stevedore physically handling the goods. The shipping agent also contacts the providers of additional services to the vessel, and pays their fees for services rendered. Figure 5 illustrates the interactions with the shipping agent.

Figure 5. Shipping agent



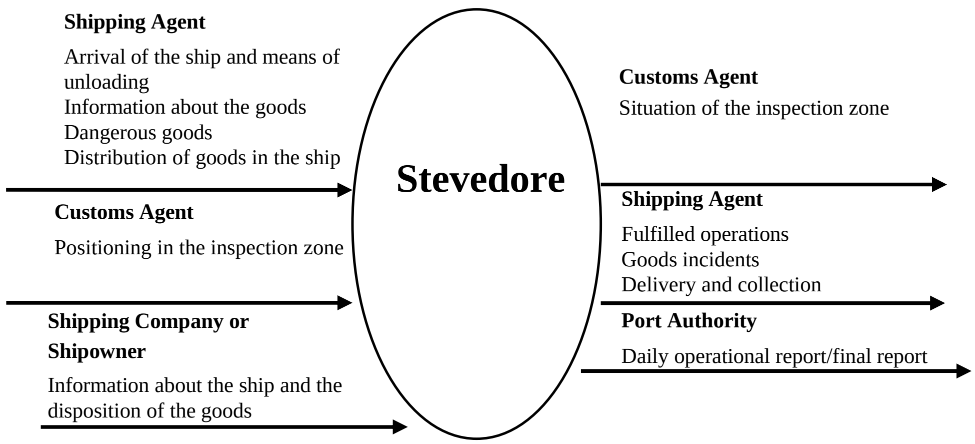
Source: Project of Restructuring the Egyptian Ports: The First Report (Ministry of Transport, Egypt, February 2001).

3. *Stevedore*

The stevedoring company is the entity responsible for the handling of goods, interfacing between the two nodes of transport, namely, sea and land. Functions are quite specific: for boarding, they include receiving, loading and stowage, and on landing, they comprise dispatch and delivery of goods.

The stevedore receives main instructions from the shipping agent, though part may come directly from the shipping company. In order to prepare for the appropriate means of dispatch and stowage, the stevedore must know the vessel arrival time, cargo details and the status of consignees and customs clearance, as well as any relevant information concerning other entities involved. Should the goods be arriving by land, part of that information is received from the haulier carrying out the delivery. Figure 6 illustrates the interactions with the stevedore.

Figure 6. Stevedore

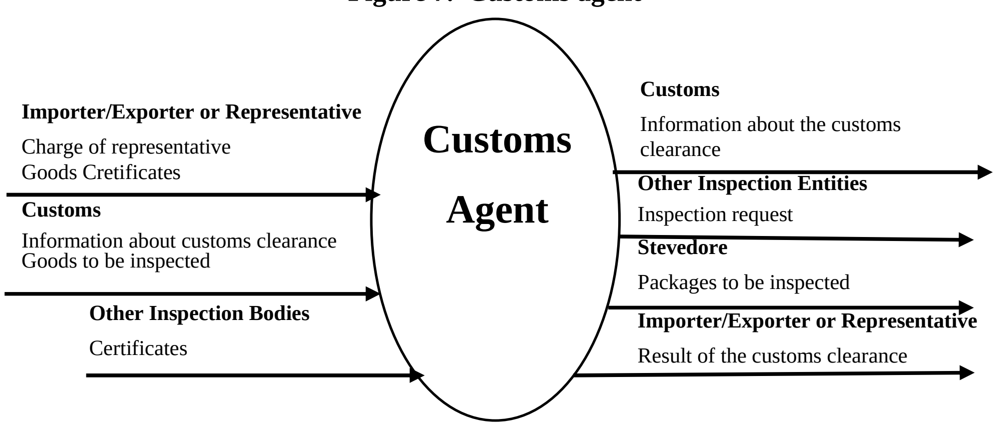


Source: Project of Restructuring the Egyptian Ports: The First Report (Ministry of Transport, Egypt, February 2001).

4. *Customs agent*

The customs agent undertakes the required procedures for clearance of goods for importation, exportation and transit. The agent is responsible for presenting all required documents to the customs authorities and, when required, for facilitating inspections, as well as handling the payment of tariffs and taxes. The customs agent represents the owner at the customs authorities, and needs to be available at all times to answer queries and resolve any problems that may arise. In order to undertake all those responsibilities, the customs agent requires the necessary information. Figure 7 illustrates the interactions with the customs agent.

Figure 7. Customs agent



Source: Project of Restructuring the Egyptian Ports: The First Report (Ministry of Transport, Egypt, February 2001).

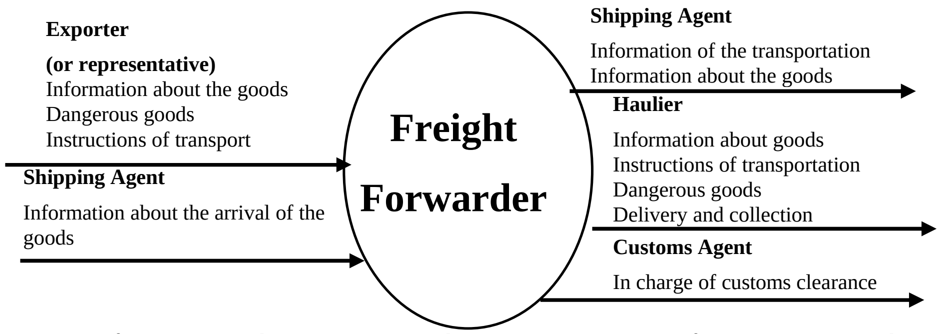
5. *Freight forwarder*

The freight forwarder is responsible for coordinating the transportation of goods from the place of origin, namely, the exporter, to the destination, namely, the importer. The freight forwarder interacts with all other agents who at any time may have a relation with the goods or its handling, and is in contact with the shipping and customs agents, the hauliers and stevedores, and the exporter and importer.

Usually, the freight forwarder works with a correspondent abroad in order to better control the transaction, as he carries the sole responsibility for the transport of the goods from origin to destination. There may be different freight forwarders for the various legs of the voyage; hence, it is important that all entities know who is responsible at any given point. Where the freight forwarder is also the haulier, the information flow becomes an internal one. The freight forwarder needs to be continually updated regarding the situation of the goods in order to act promptly should the need arise.

Generally, it is the freight forwarder who provides the exporter with the necessary information about the goods, shipping instructions and delivery conditions, as well as supplementary information and documentation. Communication with the shipping agent allows for coordination of the maritime transport of the goods. Regarding land transport, delivery and collection, the freight forwarder either undertakes those tasks, or coordinates with the haulier. Figure 8 illustrates the interactions with the freight forwarder.

Figure 8. Freight forwarder

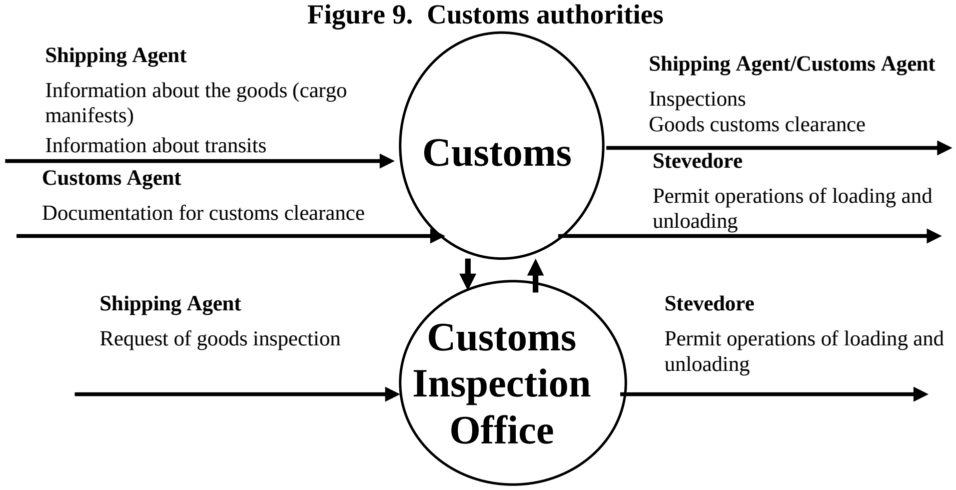


Source: Project of Restructuring the Egyptian Ports: The First Report (Ministry of Transport, Egypt, February 2001).

6. *Customs authorities*

The main function of the customs authorities is to apply export and import laws and regulations, ensuring that no exported or imported goods are released or cleared unless conditions and limitations of the foreign trade policy of the country in question have been complied with and dues collected. Figure 9 illustrates the interactions of the customs authority.

Figure 9. Customs authorities



Source: Project of Restructuring the Egyptian Ports: The First Report (Ministry of Transport, Egypt, February 2001).

B. RE-ENGINEERING PHASES AND TASKS

A key element in enhancing port performance is analysing the information flow in order to assess which pieces of information are legitimate and reasonable in respect of the functions of each party. With trade practices in transition and new strategies emerging for trade and logistics systems, functions are changing. That means that the analysis has to start with the business objectives of each entity, namely, policy, regulatory and commercial issues. After identifying the documents exchanged between port community members, business process re-engineering is required to continuously improve the workflow process and performance. When bottlenecks are identified, a committee, comprising such external members as management and technology experts, customers and representatives of affected organizations, would cooperate with the re-engineering team to tackle those obstacles. The various phases of the re-engineering process and respective tasks are presented in table 3.

TABLE 3. RE-ENGINEERING PHASES AND TASKS

Phase	Tasks
Planning and start-up	Identify key business drivers for change and assess the consequences of not changing Identify critical processes for re-engineering Identify senior management sponsors and create a steering committee of key port community entities Gain senior management support Prepare a project plan: define the scope, establish measurable objectives, select a methodology, and set a schedule Obtain agreement with senior managers on project objectives and scope Select consultants or outside experts Arrange a project launch meeting
Study of current status	Conduct customer interviews and set up focus groups to identify current and future needs Interview employees and managers to understand issues and brainstorm ideas for change Research current industry trends and best practices Document "as-is" processes at a high level and collect performance data to identify gaps Review technology changes and options Attend workshops or seminars Gather data from external experts and consultants
Design proposed solution	Brainstorm new and innovative ideas; use creative thinking exercises to think "outside of the box" Conduct "what-if" scenarios and applied "success templates" used by other ports Generate three to five models by using functional experts; develop a hybrid model by taking the best of each Create vision of ideal process Define new process models and flowchart those processes Design organizational model to align with new process Define technology requirements; select platform that would enable new processes Define standard documents to be used Separate short- and long-term improvements
Approval	Prepare cost and benefit analysis; determine return on investment Assess impact on customers and employees; assess impact on competitive position Prepare a formal business case for senior managers Review meeting to present findings to steering committee and senior managers for approval
Implementation	Complete detailed design of processes and organizational models; define new job roles Develop supporting systems Conduct pilot solutions and small-scale tests using work flow management system Communicate new solution to employees; develop and implement change management plan Develop a phased implementation plan and implement the solution Develop a training plan and train employees on new processes and systems
Monitoring and evaluation	Define key measures to evaluate periodically; measure the results of the new process; implement a continuous-improvement programme for the new process Issue final report to steering committee and senior managers

Source: Project of Restructuring the Egyptian Ports: The First Report (Ministry of Transport, Egypt, February 2001).

IV. SELECTING AN ICT PORT SOLUTION

An ICT port system is not a standard application that can be purchased as is, but has to be made compatible with the overall ICT environment. The application must be able to integrate data from all existing operational and administrative subsystems, and be customized to handle the specific information requirements of the port community. Therefore, information needs must be analyzed and defined before specifications for any standard operational or administrative ICT solution can be issued, determining the structure of the module. The specifications for standard applications or packages can then be amended by specific interface modules provided by the vendor.

A. FACTORS TO CONSIDER WHEN SELECTING AN ICT SYSTEM

1. *Business parameters*

Port management covers several business areas, including those affecting the main function of the port, those directly affecting customer satisfaction and those aiding decision makers. When selecting an appropriate ICT system for port management and operation, the choice of key equipment and components depend on the following factors: the level of automation required and the areas of operation to be covered; the physical locations of system control points; the level of security needed and maximum downtime tolerated; volume and type of data, including online versus offline; and budget limitations. Those factors will also determine the selection of other technical components essential for the solution, from such basic equipment as servers, to applications and online analytical processing tools.

The level of automation can vary according to the number of online operations performed in the work cycle, and whether implementing a paperless procedure is the ultimate target. The locations to be linked are specified according to which business fields are to be covered. Parameters and specifications of the required tools and equipment of the system control points are determined according to distance between each; whether they are indoor or outdoor, fixed or moving; and whether they are to be accessed by port community members, customers, or both.

Software, communications and equipment parameters are affected by the level of security required. Each business field should be designated a specific level of security according to the type of data to be handled and the nature of users, whether services are web-based or not and the anticipated level of security breach, including hacking. The maximum downtime tolerated for each business field affects backup and recovery policy and disaster recovery policy.

The nature of the data, whether documents, photographs or multimedia, the volume of data to be stored and/or communicated between control points and historical data to be archived all affect the business parameters. Furthermore, the number and category of users and budget limitations must be taken into account, all of which heavily affect the scope of work and the feasibility of the project and solution.

2. *Technical parameters*

ICT components of a port operating system should have the following features:

(a) Real-time persistent processing;

(b) High availability;

(c) Flexibility to accommodate changes in business flow, partner agreements and information exchanged, as well as load balancing for even request distribution across multiple resources;

(d) Scalability to accommodate large volumes of transactions without processing delays, as well as for the system architecture to be extended with multiple brokers;

(e) Extensibility to accept new heterogeneous systems;

(f) Reliability and fault tolerance to provide end-to-end transactional integrity and guarantee event delivery, ensuring reliable integration across the network by providing automatic queuing of messages. Furthermore, the system should withstand the “pull-the-plug” test without loss of a single event and minimum downtime;

(g) Full compatibility with EDI and extensible markup language (XML) standards, without proprietary extensions that restrict the ability to integrate with partners; in addition to integration methodology to guide the process, eliminating risks and unnecessary delays;

(h) Connectivity to popular front- and back-office databases and legacy systems through pre-built adaptors.

ICT components should provide an accessible user interface for administration, data analysis tools, statistics reporting and wireless web connection from any device. The system should include other such technical features as parameters for the application, security, web server, operating system and online analytical processing and data mining tools.

(a) *Applications*

The recommended application system should be open to satisfy functional requirements and provide or design practical implementations that can supply the connectivity, including inter-operability and portability to accommodate future technological development. It should use modern software development tools and ensure that conceptual and physical data-models, namely, relationship diagrams including repository and data dictionary, are made available to ICT staff of the port community members. The application system should be open to any relational database management system, including the ability to access data of other internal port applications for two-way integration of information, namely, data-import from and data-export to other database management systems. Moreover, the solution should be delivered with complete system and user documentation in print format; provide a high level of data integrity and access security in order to maintain confidentiality; and have adequate features for downloading data, for example spreadsheet and similar modules.

Furthermore, the following features should be included:

(i) Graphical user interface;

(ii) Full recovery functionality in case of system failure;

(iii) Multi-user applications, allowing for multiple concurrent users to access and update information on record level;

(iv) Structure query language standards to enable for ad hoc queries;

(v) Report generator for defined and customized reporting in flexible output design, for example combined fields or group output with defined field length, font type and size;

(vi) Full online help facilities, providing menu-driven and/or context-sensitive help whenever required by user.

(b) *Security*

A computer system which integrates multiple parties with different responsibilities should be guarded by various levels of security systems. The required security attributes for the proposed solution are defined as follows:

(i) Confidentiality: protects sensitive information from being viewed indiscriminately;
(ii) Integrity: guarantees that information is not tampered with or altered;
(iii) Availability: ensures data is available when and where expected;
(iv) Authentication: verifies the identity of communicating parties;
(v) Access control: determines who may have access to information within the system;
(vi) Authorization: authorizes the user to either view or manipulate the data;
(vii) Auditing: verifies when and where a transaction took place;
(viii) Non-repudiation: is unable to deny a transaction;
(ix) Encryption: encrypts messages for protection;
(x) Global sign-on: provides a single point of entry to disparate networks.

The security policy of any computer system depends mainly on the security of the applications, the network, the operating system and the database.

(c) *Web application servers*

The following parameters need to be met:

(i) Scalability to accommodate variations in volume of client requests and in web traffic through using clustering features and offering reliable run-time environment;

(ii) Load balancing for even request distribution across multiple resources;

(iii) Security features, including authentication, secure socket layer, certificate, access rights and encryption;

(iv) Zero downtime;

(v) Flexibility and openness in overall architecture, providing an integrated development environment and accommodating dynamic online configuration changes; as well as including remote and local system for administration, management, prototype testing and system monitoring, and the use of external tools;

(vi) Platform/operating system and database independent.

Such features as statistics reporting and wireless web connection are advantages to be considered.

(d) *Operating systems*

The operating systems of the servers should be industry standard UNIX multi-user, multitasking to control all system resources in an efficient way. They should support the different modes of operation, namely, interactive processing, online processing, batch and transaction processing modes. The following parameters should be satisfied:

(i) Provide virtual memory management;

(ii) Monitor power supply and communications;

(iii) Support unlimited number of logged-in users;

(iv) Allow job priority setting, auditing and online activity supervision;

(v) Provide security features;

(vi) Provide interactive system management and operation for use in monitoring all components, devices, tasks and users;

(vii) Provide spooling;

(viii) Provide system recovery and automatic file system recovery, as well as backup and recovery;

(ix) Provide workload management over processor, memory and input/output resources.

(e) *Online analytical processing and data mining tools*

Online analytical processing tools require the following key features:

(i) Multidimensional views of data;
(ii) Calculation-intensive capabilities;
(iii) Time intelligence;
(iv) Rapid deployment.

3. *Organizational parameters*

A prerequisite for selecting an ICT port solution, be it a central database or port operating system, a message exchange broker system or a combined system, is a thorough analysis of the organizational responsibilities among all port community members. Users and user-groups need to be identified and authorization access to confidential information defined in order to establish a comprehensive index of codes. Once information needs are analysed and defined, specifications can then be amended to suit the particular environment and requirements of the port organization.

(a) *Workflow*

The workflow of the business management of the port authority should be studied and carefully integrated with all other entities to synchronize the completion of procedures and transactions in the shortest possible time. To achieve that, primary planning of the workflow of the following procedures is needed: (i) vessel arrival, including berthing, control centres and marine services; (ii) vessel departure, including control centre authorization; (iii) income, including issuing of port invoices and linking those with all other parties and with banks for automatic cashing; (iv) vessel loading and unloading; (v) gate operations; (vi) import, including general cargo, liquid bulk cargo, containers and roll-on roll-off; (vii) rail loading and dispatch; and (viii) EDI.

4. *Data and message exchange parameters*

(a) *Data exchange tools*

(i) *Integration*

EDI-and XML-enabled modules should include a mailbox system that allows port community members and customers to send and receive messages. Legacy systems require ready-made adapters for the most commonly used databases or applications, or customized adapters for other lesser-used applications in order for users to integrate. The message exchange platform provides flexibility in integrating modern and legacy systems. Referential data, for example port codes, can cause problems in communication. Though international standards are preferred, in reality not all port community members may be ready to undertake such a comprehensive implementation. Applying an integration platform provides them with a tool for translating sender codes. By having the business workflow implemented on an integration platform, any delays can be analyzed through process monitoring features. In addition, statistics can be generated using the process analysis to reveal crucial business performance indications.

(ii) *Routing*

Routing should facilitate message transfer according to customizable rules defined by the port community, allowing for intervention, notification and once-only document delivery. The integration platform routes messages to the required destination. Multidestination routing, also known as publish-subscribe feature, allows the sender to publish a message and all interested parties to receive that message, eliminating the need for point-to-point integration. Content-based routing scans the message fields and determines destination identity, thus transmitting various exchanged documents using one definite schema or document.

(iii) *Transformation*

The data translator should provide mapping and conversion of data value, name, type, payload format and semantic transformation. In order to guarantee successful communication, exchanged messages must be according to agreed-upon standard formats. That can be achieved by applying the any-to-any feature, which provides the translation dictionary between communicating parties. The platform translates between different integrating parties, thus converting the language of the sender to that of the receiver and transforming different data representations and document formats, for example XML, EDI, Microsoft Office Excel and flat files.

(iv) *Storage*

The data exchange tools should include a mailbox system to store incoming messages in a persistent queue for subsequent delivery and processing, with a scheduling feature to ensure high priority messages receive due attention. The system should also include auditing modules for such components as receiving and dispatch times to be stored, warehoused, queried or audited, as well as providing transaction history, data tracking and data tracing.

(v) *Partner management*

The system should maintain a profile for each port community member, storing information on configuration security and communication, and messages to be exchanged with other members or customers.

B. RECOMMENDED IMPLEMENTATION STRATEGY

While the initiative should come from one or more of the major port entities, the implementation of an automated system for the management and operation of various port functions is often the responsibility of a company specifically founded by the port authority for that purpose. In some cases, major operations are concentrated with the port authority; in other cases, port community members act on a cooperative basis. Where several parties are involved in organizing such an implementation project, and those parties are of varying size, it is often most practical to form a separate company for that purpose. The advantages gained thereby are mutual, as participation is assigned based on parts or shares corresponding to respective project interest and/or company size; thus, such a designated company reflects the balanced interests of all parties involved. In addition, setting up a separate company ensures flexibility and allows for subsequent expanding of the number of participants and the number and type of transactions. Moreover, new capital can be raised whenever needed for expansion of activities.

The recommended strategy for ICT implementation and EDI for port operations in the ESCWA region is the combined system, installed through an initial message exchange broker module with a subsequent extension of services. As illustrated in table 1, that system is the chosen strategy adopted by most highly automated, international ports.

1. *Initial stage: message exchange broker system*

The message exchange broker system should serve the whole port community, allowing for real-time communication and message exchange, including data, information and documents, in an intermodal community. Through the message exchange broker, all members of the port community are linked by a network; thus, the system will provide the following functions:

(a) Electronic exchange of documents and information;
(b) Assured and controlled data access and dispatch;
(c) Conversion and standardization of transmission formats;
(d) Duplication and sorting of single messages to receivers;
(e) Value added services;
(f) Interconnection of users to certification bodies for electronic signature;
(g) Certification of message dispatch and delivery, and record-keeping of data and documents.

There are two alternatives to establish a message exchange broker for the maritime community, namely, a single message exchange broker and several message exchange brokers.

(a) *Single message exchange broker*

A single message exchange broker is established to conduct the functions required for electronic messaging exchange. It is recommended that the Ministry of Transport issues a request for proposal (RFP) inviting private operators to handle EDI through either an existing module or a newly-established system set up according to specifications defined by RFP. Terms are negotiated and a concession agreement is signed between the ministry and the private operator.

The private operator works on behalf of the ministry to provide EDI services for all port and related entities, including customs, shipping agents and terminal operators. In order to attract and encourage bidding, the port authority should promote those services to government institutions and port community members. For example, shipping companies and agents would be required to become partners in order to exchange EDI and non-standard messages with other port community members.

The following are some of the advantages of implementing a single message exchange broker:

(i) One message exchange broker is required to serve the whole port community and all its members, enabling them to deal with local and foreign trading partners through a unified software module, standard and user interface;

(ii) One database receives, stores and transmits all messages, making it easy to apply ICT tools for business analysis and message content after decryption;

(iii) One centre eliminates the need for data conversion from an intermediate format to another, thus saving time.

(b) *Multiple message exchange brokers*

The port authority, through RFP, invites a private operator to handle EDI through message exchange brokers. Modules can either be the existing systems or applications implemented according to RFP specifications. Thus, more than one message exchange broker may be established to deal with the port community for common business processes and document exchange. Any agreements previously undertaken by the port authority with a specific vendor can be accommodated; thus, members are free to choose their own operator by inviting a separate RFP.

The following are some of the advantages of having multiple message exchange brokers:

(i) Competition improves service quality and reduces charges through avoiding monopoly of one broker;

(ii) Distribution of workload and data on several brokers increases productivity and efficiency;

(iii) Alternative message exchange platforms increase reliability.

(c) *Comparison*

Table 4 presents a comparison between the use of single/multiple message exchange brokers.

TABLE 4. COMPARISON: SINGLE/MULTIPLE MESSAGE EXCHANGE BROKERS

Comparison	Single message exchange broker	Multiple message exchange brokers
Data statistics	Easier to extract data from one source	More tedious and complex to gather and coordinate data from several sources
Traffic	For high loads, an increased number of servers may be needed and load balancing methods performed	The load is normally distributed among several centres according to the number of subscribers at each centre
Reliability	More risky as failure would cause loss of all messages, unless handled by a second duplicate centre at another geographical location	Less risky as failure at one centre would cause loss of messages there only, while messages at other centres are safe
Service market	Monopoly of service may control quality and price	Competition would lower the cost
Security	Same security methods are applied in both alternatives, namely, encryption and digital signature	Same security methods are applied in both alternatives, namely, encryption and digital signature
Data conversion	Standards are uniform, thus eliminating data conversion of different formats	Data conversion from one format to another is required, which may slow down the operation

Source: Project of Restructuring the Egyptian Ports: The Second Report (Ministry of Transport, Egypt, June 2001).

V. PORT OF ALEXANDRIA

The objective of this chapter is to present a case study on the use of ICT in the maritime field. The selected example of a model port operation in the ESCWA region is the Port of Alexandria, Egypt. The processes and applications mentioned either have been implemented and are in operation, or are planned to be applied within in the short term.

A. CHALLENGES AND OBJECTIVES

The Alexandria Port Authority had been faced with a multitude of challenges, leading to the proposal of implementing ICT in the management and operational procedures of the port. With a large number of entities involved in administrating port services, customers had been required to deal with several entities, each affiliated to their respective administration or ministry with specific laws and regulations. Sharing data and information within and among port community members would lead to better service, achieved through directing all port community customers to one location for document submission, vessel and cargo monitoring and billing.

ICT-related challenges included sourcing a vendor specialized in maritime ICT, handling a project of a magnitude much greater than other ICT projects being executed in Egypt, and assimilating systems already in place to develop a comprehensive, stand-alone solution. Cultural challenges were faced when changing existing ways of handling tasks and applying operating norms, all closely related to the laws and regulations of respective ministries.

To manage a change from old practices required support from senior levels within the Egyptian Government, something the Alexandria Port Authority had recognized from the beginning. In fact, the initiative came from the port management and was supported by the Ministry of Transport, hence the coordination started on a ministerial level. A steering committee was formed, composed of heads of port community entities and supported by the ministers under whose jurisdiction each entity fell. Meetings were held at least once a month to follow up on progress and help in overcoming obstacles. In addition, progress meetings were held twice a week to enable sponsors and the execution team to discuss various operational problems.

Through limited tender, a company was selected to execute the project, including design and software, and to provide consultation for infrastructure sub-projects, including infrastructure and equipment directly related to ICT required in order to meet the design objectives. Following a preliminary study, components and execution plans were identified.

B. PROJECT PLAN AND COMPONENTS

The project comprised the following components:

(a) Business process analysis and re-engineering;

(b) Software development and applications to support the redesigned processes, and ICT infrastructure to support both the re-engineered business processes and the software applications;

(c) Civil and related infrastructure to support the re-engineered business processes and the required ICT infrastructure;

(d) Human resources to operate and maintain the system.

C. BUSINESS PROCESS RE-ENGINEERING

The business process re-engineering was the core of the project. The team responsible had experience in maritime operations, including maritime ICT, and had also been involved in ICT design for various business processes in other sectors. Most importantly, the team had full support from the senior management of the Alexandria Port Authority.

The re-engineering process began by defining the objectives of each port service, namely, defining services to be provided to customers regardless of previous practices. The role of each entity was defined, as were the reasons that entity was needed and who the primary owners of the various functions and data were. Answers given set the parameters of the re-engineering process. Meetings were held with respective representatives to analyze the situation and identify workflow bottlenecks and deficiencies. Preliminary outlines were presented to the steering committee meeting for feedback and approval. Once plans were passed on to the ICT software and infrastructure experts to design and refine, the following redesigned workflows were identified:

1. *Vessel movement*

Vessel movement workflow is related to all aspects of vessel operation, from notification from the shipping agent of expected time of berthing to payment of all services provided for the vessel. The many stages and tasks of the vessel workflow include steps and procedures:

(a) Notification of expected vessel arrival and manifest delivery;

(b) Berth planning based on set parameters;

(c) Planning of marine and stevedoring services;

(d) Monitoring of vessel movement from time of arrival at outer anchorage, through movement within the port, to vessel departure;

(e) Security, customs and maritime inspection, as well as health quarantine services;

(f) Billing and e-payment processes related to all services received.

2. *General cargo import*

The Port of Alexandria receives a wide range of cargo, including cars and livestock, which exists in many forms, from liquid bulk, powder and granules, to pallets, cartons and bags. The import cycle includes the following steps and procedures:

(a) Planning of cargo location in yard and warehouse;

(b) Vehicle booking, weighing and movement within the port area;

(c) Cargo declaration, inspection, classification and clearance by customs and cargo inspection authorities;

(d) Cargo movement from and to vessel and yard;

(e) Cargo movements from and to yard and gate;

(f) Billing and e-payment for cargo inspection services by the civil defence, port authorities and customs, as well as services provided by warehousing companies.

3. *General cargo export*

At the port, the exporting of cargo includes the following steps and procedures:

(a) Declaration and clearance of general cargo export;

(b) Cargo planning in yards and warehouses;

(c) Vehicle booking, weighting and movement within the port area;

(d) Cargo movement from and to yard and vessel;

(e) Billing and payment collection processes for various services provided by the civil defence, port authorities, customs and cargo inspection authorities and warehousing companies.

4. *Container import*

At the Port of Alexandria, containerized cargo is handled by various entities in the port community and represents about 45 per cent of total cargo. The container import cycle includes the following steps and procedures:

(a) Planning of container location on vessel and in yards;

(b) Vessel planning;

(c) Yard planning;

(d) Vehicle movement inside and outside container terminal;

(e) Handling of hazardous and other special cargo;

(f) Declaration, inspection, classification and clearance of containers by customs and cargo inspection authorities;

(g) Vessel and shore operations;

(h) Yard control operations;

(i) Gate operations;

(j) Billing and payment collection processes for various services provided by the civil defence, port authorities, customs and cargo inspection authorities and warehousing companies.

5. *Container export*

The container import cycle includes the following steps and procedures:

(a) Declaration and clearance processes of exported containers;

(b) Planning of container location in yards and on vessel;

(c) Vehicle booking, weighting and movement within the port area;

(d) Billing and payment collection processes for various services provided by the civil defence, port authorities, customs and cargo inspection authorities and warehousing companies.

6. *Passenger traffic*

The operations at the Port of Alexandria include the handling of passenger vessels and cruise ships. The processes specifically related to such vessels, including police and immigration services, were added to the normal procedures.

D. SOFTWARE APPLICATIONS AND COMPONENTS

1. *Software application*

Software applications were selected, developed or modified in order to support the re-designed processes. Integration was needed between different port community members and their related divisions. After studying the port community as a whole, entities were grouped into the following three categories according to their respective ICT needs:

(a) Entities which, in order to participate, require operating systems to handle internal work, namely, the port authority, one of the container terminals and the police;

(b) Entities with systems already in place, but requiring some modifications in order to operate a real-time system and to work or communicate with other port community members, namely, customs, cargo inspection and maritime safety authorities;

(c) Entities requiring complete systems for communication, use or input through a web portal, namely, agents, transport companies, importers and exporters.

Furthermore, a platform to exchange data between entities was needed to enable communication between all port community members. The port selected Smart Port Solutions (SPS) software, provided by Integrated Solutions for Ports (ISFP). SPS is an integrated port operating system, integrating all terminals within the Port of Alexandria with such entities as customs, police and other institutions handling import and export control, as well as bank operations within the port area.

The system includes the following modules:

(i) SPS-Harbor, which handles vessel movement and related workflow, including berth planning and marine services; actual vessel movement and related services; and vessel release according to set parameters;

(ii) SPS-Warehousing, which handles warehousing functions from authorized warehousing companies, including yard planning for both imported and exported goods; recording of cargo movement in warehouses and yards; and handling of hazardous cargo;

(iii) SPS-Billing, which converts transactions into bills, serving all other modules;

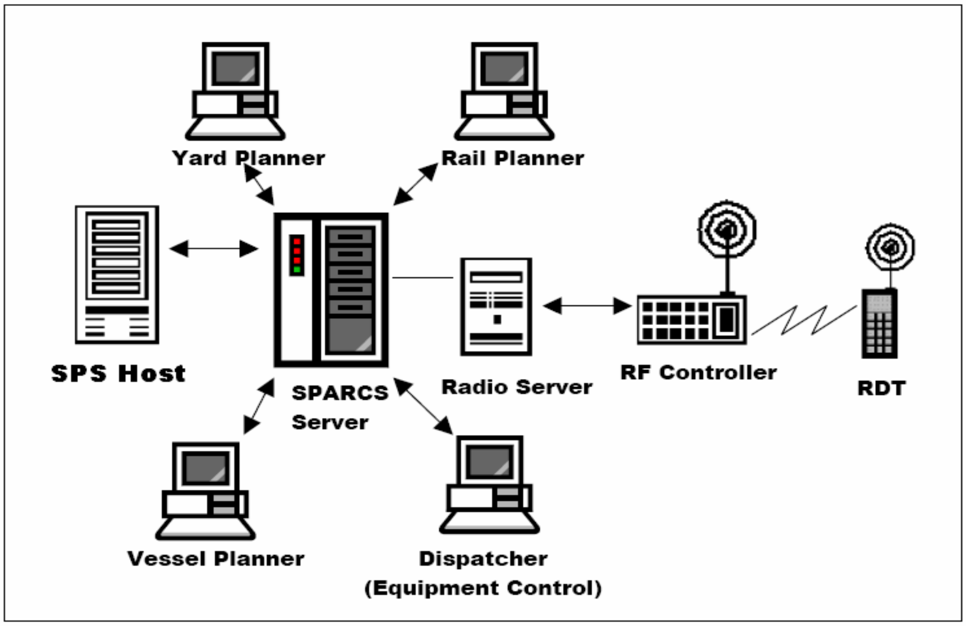
(iv) SPS-Stevedore, which handles cargo movement from vessel to vehicle and vice versa, including cargo handling and equipment organization and planning;

(v) SPS-Safe, which serves the police authorities in their various functions within the port area, including crew monitoring, passenger clearance, cargo-storing functions and international ship and port facility security procedures;

(vi) SPS-Messaging, which is an interface linking the core system and the message exchange platform to enable message transmission from or to core SPS modules; and

(vii) SPS-Cont and Navis SPARCS, which handle container terminal operations. SPARCS is the interface and acts as a graphical front-end for container handling operation and planning; SPS acts as back-end communication enabler with external parties and is responsible for storing and retrieving all data. The connectivity is illustrated in figure 10.

Figure 10. SPS-Cont/SPARCS connectivity



Source: ISFP: Smart Port Solutions (SPS) technical documentation.

Notes: RF: Radio frequency.
RDT: Radio data technology.

2. *Message exchange platform*

With many independent entities serving the Alexandria Port Authority in various fields, the aim of introducing an automated system was to re-engineer the existing processes in order to ease the workflow and better serve the port customers. For example, before re-engineering, berthing request documents had to be handed in to several port authority offices, including transport, finance, customs, marine safety and the police, as well as to stevedoring and warehousing companies. After the re-engineering process, documents are handed to the logistics centre and, following approval, the message exchange broker distributes them to all entities concerned. In other words, e-documents are created and extracted from the sender system, then distributed to the receiver through the message exchange engine, as illustrated in figure 11. The Alexandria port community members have systems compatible with those at all other Egyptian ports.

The message exchange platform, with a large set of connectors, can perform several functions, including the following tasks:

(a) Distribute e-documents and messages between parties based on header and content;

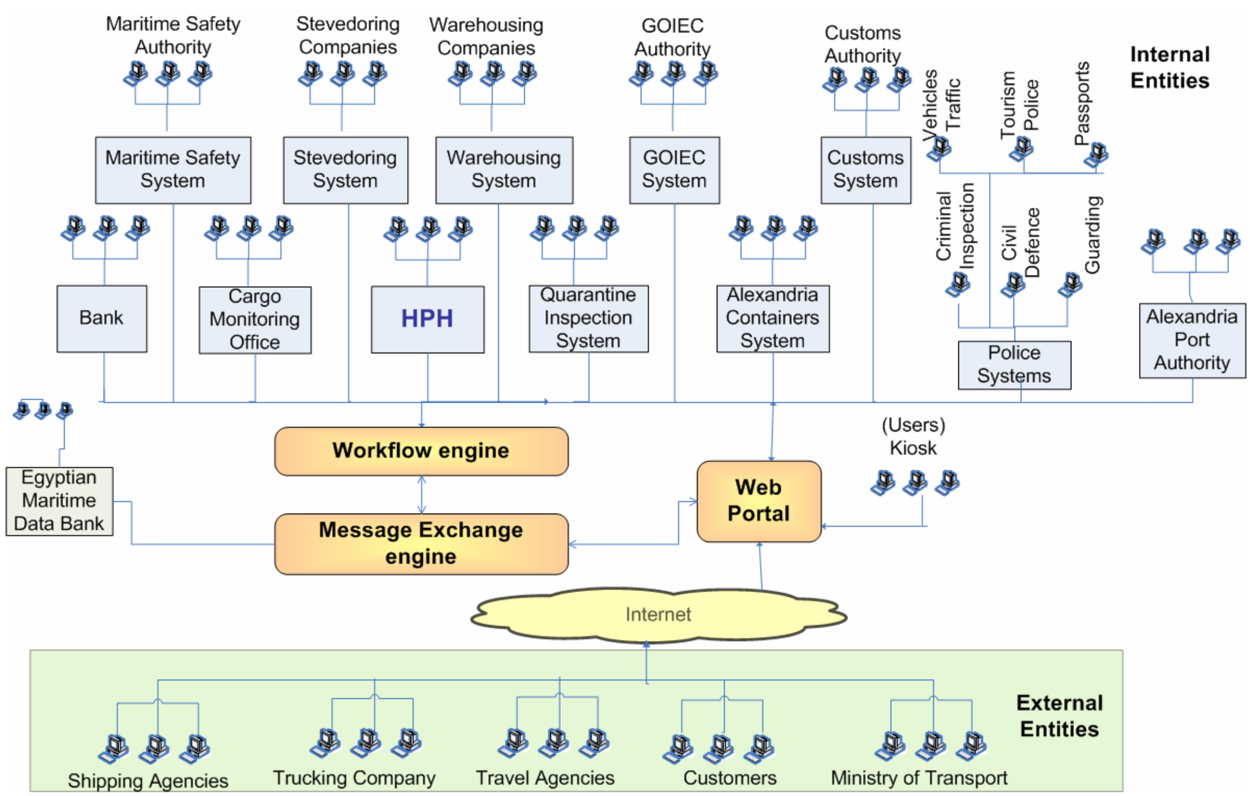
(b) Validate messages according to pre-designed templates and context in the workflow;

(c) Log and monitor messages sent and received for future reference;

(d) Transform, whenever needed, messages into various formats, including pre-designed, XML, EDI and Excel or comma delimited;

(e) Map various system reference data to standard format as each entity has its own interface.

Figure 11. Port community entities



Source: ISFP: Smart Port Solutions (SPS) technical documentation.

Notes: GOIEC: General Organization for Exports and Imports Control, Ministry of Trade and Industry, Egypt.

HPH: Huchison Port Holdings.

E. INFRASTRUCTURE AND COMPONENTS

The ICT infrastructure installed at the Port of Alexandria is complex, and technical details are beyond the scope of this *Study*.

The infrastructure supports the business processes so that port community members are able to store, process and communicate their business transactions. For example, berthing requests need to be stored or sent on to different entities, and acceptance needs to be based on the availability of such information as credit limits for shipping agents. The system must be available to support online operations around the clock, for example container discharging and loading.

High ICT management standards have been applied regarding problem resolution, software deployment, security and configuration management. ICT security is a major prerequisite for live operation, with each transaction tracked to its origin, and protects the system from unauthorized intrusion from Internet and internal users.

1. *Infrastructure architecture*

The ICT infrastructure architecture is illustrated in figure 12. Information and data are distributed around the port through the following means:

(a) *Data centre*

The data centre is the main part of the ICT infrastructure, comprising the servers and the network devices. The following types of servers have been implemented:

(i) Database servers, which are clustered to jointly operate in order to support all transactions, ensuring uninterrupted workflow should one server fail;

(ii) Application servers, which operate SPS and integration software;

(iii) Connectivity servers, which operate the message exchange platform and its connectors;

(iv) Navis SPARCS and radio data technology servers, which operate the container terminal;

(v) Other control devices, including domain controllers and mail, web and anti-virus servers.

The network devices include a main core switch, which connects all port network devices and devices which control external connections and network security.

(b) *Wired network*

The wired network connectivity to different buildings allows transactions executed at various places to be collected and consolidated in the main database. Logistics centres, including one-stop-shop and administration buildings for back office and inspection, are connected to the main database servers. More than one hundred locations around the port area are connected.

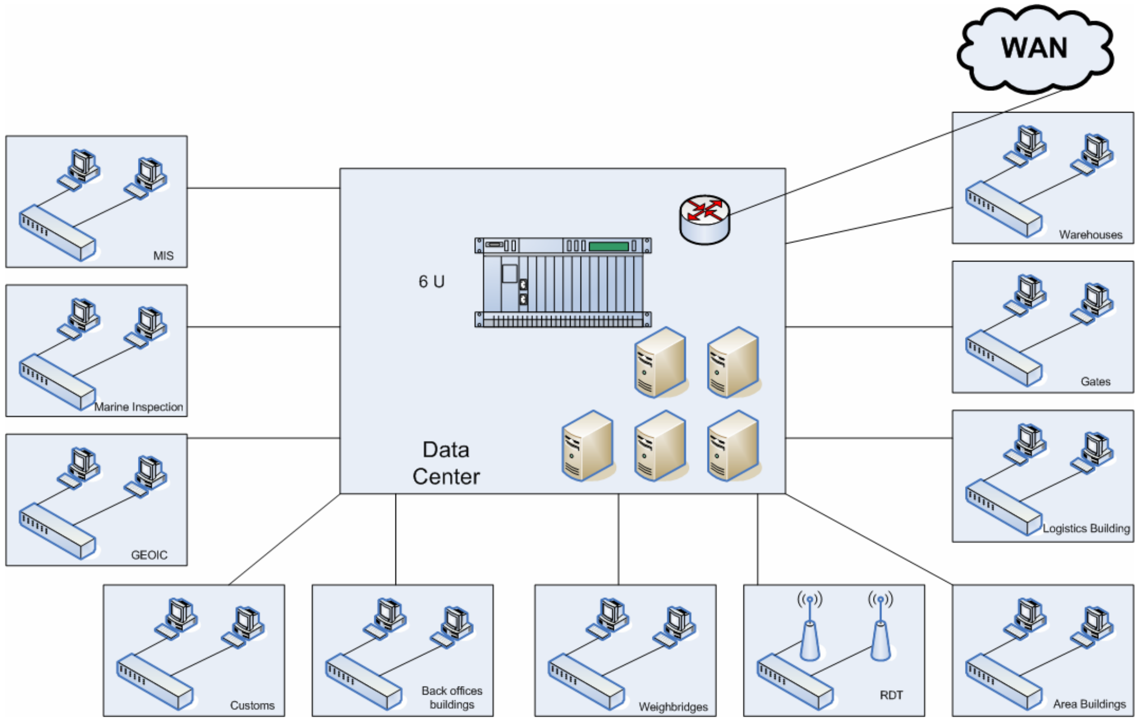
(c) *Wireless network*

The wireless network extends coverage to those areas which cannot be reached by the wired network. Data from berths, yards and warehouses are transmitted by radio data technology devices in real time. The wireless coverage is done through wireless Internet access (Wi-Fi) technology, and users handle mobile devices with applications to capture such transactions as vessel, cargo and container movement and inspection.

(d) *Internet connectivity*

Internet connectivity is essential for the web services handling information exchanges from port customers and external support companies. Users working from their external offices have access to port services and information.

Figure 12. System architecture



Source: ISFP: Smart Port Solutions (SPS) technical documentation.

Notes: MIS: Management information system.

GEOIC: General Organization for Exports and Imports Control, Ministry of Trade and Industry, Egypt.

RDT: Radio data technology.

WAN: Wide area network.

2. *Components*

(a) *Logistics centre*

A new main office and administration building was constructed in order to offer port customers a single location in which to present documents or request services, and in order to provide separate visitor areas, because customers are not allowed to interact with back-office staff.

The logistics centre, or one-stop shop, is the front office for port community customer services, including the port and customs authorities, vessel, cargo and container inspection, and bank representatives. Port customers go to that location for service, requests, queries or follow-up. While the same services are offered through the Port of Alexandria web portal, certain documents will continue to require personal presentation until certification of e-signature has been finalized.

(b) *Data centre*

The data centre is the core of the system and each port community member is represented. The main function there is back-office operations and staff do not deal directly with port customers. The ICT team, whose members are technically trained and experienced, support the whole ICT system. Any problems encountered by end-users are captured by the support desk and forwarded to the responsible section for action.

(c) *Area control buildings*

Area control buildings are replicated around the port area. Members of inspection teams go to the nearest area control building to key in information and data, which are then consolidated into the system.

(d) *Gates and weighbridges*

Port and terminal gates are essential for access to the port area and vehicles require bookings for delivery or pick-up of goods. The main functions are:

(i) To identify and control vehicle movement in and out of the port area;
(ii) To direct vehicles to quays, yards or warehouses;
(iii) To ensure security procedures have been followed.

Through a link-up to the weighbridges, control of road utilization and monitoring of cargo quality are achieved.

F. HUMAN RESOURCES

Human resources play an instrumental role in all operation and management activities, and various skills are required. The following categories are involved, namely, end-users and super-users, support teams and vendor support. End-users are responsible for the day-to-day operations of the system, recording and extracting information and data. They need comprehensive training on the functions of the system. Super-users are responsible for supporting the complete business cycle. They identify and evaluate any problems occurring, and either solve them or refer them to the respective support team. The support teams are highly technically trained, in addition to having a deep understanding and knowledge of business-related issues and functions. They are crucial for the online operations and can engineer work processes to circumvent an obstacle or, until a technical solution has been completed, implement a manual process to ensure an uninterrupted workflow. More complicated problems are referred to the vendor support teams, as all vendors are liable to maintain and support components they supplied according to agreed contracts.

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