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Safaa A.J. Alfayyadh

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DEVELOPMENT OF THE FRAMEWORK FOR A LEAN, ENERGY EFFICIENT, AND ENVIRONMENTALLY FRIENDLY PORT: UMM QASR PORT AS A CASE STUDY

By

SAFAA A. J. ALFAYYADH
Republic of Iraq

A dissertation submitted to the World Maritime University in partial Fulfillment of the requirements for the award of the degree of

DOCTOR OF PHILOSOPHY
In
MARITIME AFFAIRS
PORT MANAGEMENT

2017

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DECLARATION

I certify that all the material in this thesis that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this thesis reflect my own personal views and are not necessarily endorsed by the University.

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Prof. Dong-Wook Song (Internal Assessor)

The doctoral candidate is required to bring to the attention of the approving panel any changes to the research work that may have ethical implications.

Signature(s)               Date
ACKNOWLEDGEMENTS

After an intensive period of forty months, today is the day: writing this note of thanks is the finishing touch on my thesis. It has been a period of intense learning for me, not only in the scientific arena, but also on a personal level. Writing this thesis has had a big impact on me. I would like to reflect on the people who have supported and helped me so much throughout this period. This research would not have been achievable without the help and guidance of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of this study.

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Last but not the least, the one above all of us, the omnipresent God, for answering my prayers for giving me the strength to plod on despite my constitution wanting to give up and throw in the towel, thank you so much Dear Allah.
ABSTRACT

Title: Development of the Framework for a Lean, Energy Efficient, and Environmentally Friendly Port: Umm Qasr Port as a Case Study

Degree: Doctor of Philosophy (PhD)

The research focus is to examine rigorously how the implementation of Lean within the Umm Qasr Port improves the operation processes and to explore the Lean impact on environment improvement and energy efficiency management. In this research, the ROPMEE model has been developed by the researcher to evaluate the service quality in the cargo delivery process in the Port of Umm Qasr as it covers all the functional and non-functional areas in the cargo delivery process compared to other quality dimensions. The findings confirm that the process quality dimension is the most influential factor in service quality in the Port of Umm Qasr. The reasons for the poor performance of current practices adopted by the port are the use of traditional ways of information flow and a decision-making process that requires more time and steps within the whole process. The lack of smooth process flow is a potential cause of bottlenecks within port operation that create serious problems not only for the customer but also for the port itself.

In this research, a visual representation is created of how the current value stream map for different port processes has been established on the identification and elimination of non-value-added activity or “waste” involved in delivering services in Umm Qasr port for customers. A VSM tool was applied to visually map the cargo handling flow, ship entrance, ship maneuvering and cargo clearance to display the current and future states of processes in a way that highlights opportunities for improvement. Based on the defined and classified waste according to the seven deadly wastes of Lean, this research suggests a future value stream map for port processes. The impact of the identified wastes has been quantified in terms of cost, carbon dioxide emissions working time efficiency, and energy consumption cost. This research is the first attempt to develop a Lean port model for improving port processes, as there have been no previous studies aimed at providing a holistic framework for improving port performance, which can be used by other ports.
Implementing the Lean approach requires a gradual shift in work culture by involving all port employees and customers in the continuous improvement process and changing the service delivery from a push to pull system.

**Keywords:** Lean Port, Process Improvement, Value Stream Mapping, Efficiency, Environment, Energy Management.
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<th>Description</th>
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<tbody>
<tr>
<td>AIS</td>
<td>Automatic Identification System</td>
</tr>
<tr>
<td>CFA</td>
<td>Carbon Footprint Analysis</td>
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<tr>
<td>CFAS</td>
<td>Confirmatory Fact Analysis</td>
</tr>
<tr>
<td>CSR</td>
<td>Corporate Social Responsibility</td>
</tr>
<tr>
<td>DEA</td>
<td>Data Envelopment Analysis</td>
</tr>
<tr>
<td>EDI</td>
<td>Electronic Data Interchange</td>
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<tr>
<td>ERP</td>
<td>Enterprise Resource Planning</td>
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<tr>
<td>ESPO</td>
<td>European Sea Ports Organization</td>
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<tr>
<td>EU</td>
<td>European Union</td>
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<tr>
<td>FTE</td>
<td>Full Time Equivalent</td>
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<tr>
<td>GCPI</td>
<td>General Company for Ports of Iraq</td>
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<tr>
<td>GHG</td>
<td>Greenhouse Gases</td>
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<tr>
<td>GRA</td>
<td>Gray Relational Analysis</td>
</tr>
<tr>
<td>GRT</td>
<td>Gross Registered Tonnage</td>
</tr>
<tr>
<td>HHI</td>
<td>Herfindahl- Hirschman Index</td>
</tr>
<tr>
<td>HPC</td>
<td>Hamburg Port Consultancy</td>
</tr>
<tr>
<td>IALA</td>
<td>International Association of Lighthouse Authorities</td>
</tr>
<tr>
<td>IMDG</td>
<td>International Maritime Dangerous Goods</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>JIT</td>
<td>Just-in-Time</td>
</tr>
<tr>
<td>KPIs</td>
<td>Key Performance Indicators</td>
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<tr>
<td>OEE</td>
<td>Overall Equipment Effectiveness</td>
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<td>POS</td>
<td>Port Operation System</td>
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<tr>
<td>PPIs</td>
<td>Port Performance Indicators</td>
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<td>RORO</td>
<td>Roll on/ Roll off</td>
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<tr>
<td>RTG</td>
<td>Rubber Tyred Gantry</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
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<td>------------</td>
<td>--------------------------------------------</td>
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<tr>
<td>SFA</td>
<td>Stochastic Frontier Analysis</td>
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<tr>
<td>STS</td>
<td>Ship- to- Shore</td>
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<tr>
<td>TEU</td>
<td>Twenty-Foot Equivalent Units</td>
</tr>
<tr>
<td>THC</td>
<td>Terminal Handling Charges</td>
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<tr>
<td>TOS</td>
<td>Terminal Operating System</td>
</tr>
<tr>
<td>TPS</td>
<td>Toyota Production System</td>
</tr>
<tr>
<td>TQM</td>
<td>Total Quality Management</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>UNCTAD</td>
<td>United Nations Conference on Trade and Development</td>
</tr>
<tr>
<td>U. S.</td>
<td>United States of America</td>
</tr>
<tr>
<td>VMS</td>
<td>Vessel Monitoring System</td>
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<td>VSM</td>
<td>Value Stream Mapping</td>
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<tr>
<td>VTS</td>
<td>Vessel Traffic Service</td>
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<tr>
<td>VVT</td>
<td>Vessel Turnaround Time</td>
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<tr>
<td>WIP</td>
<td>Work in Progress</td>
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1. Chapter One: Introduction

1.1. Introduction

In a perpetually changing port marketplace, satisfying the port customer is paramount to successful port business. Ports are challenged to find new methods to improve customer service through quality, efficiency and cost reduction. The retention or loss of a customer, hinges on administrative processes and non-value-added activities as parts of service transactions. It is imperative that costs are maintained (or reduced) without compromising the level of services. Factors impacting port performance include the level of technology used, infrastructure, superstructure, human factor, and management.

In recent decades, the port industry has undergone significant development, encouraged by both the legislative reforms to which it has been subjected and profound technological changes resulting in a distinct impact on cargo handling operations. The port industry is in the middle of a wide and essential restructuring. Instead of concentrating only on the conventional processes of loading and unloading cargo, ports must focus on their function in the transport supply chain.

Ports, as nodes in the global transport service, are modernized in the direction of generating multiple value-added activities, and are becoming centers of cargo flow, cash flow and information flow. Ports are not performing in the traditional way and their functions are expanding accordingly. For the purpose of expanding port functions and improving efficiency, ports must eliminate constraints with a successful management system. Efficiency signifies a level of performance that describes a process that uses the lowest amount of inputs to create the greatest amount of outputs. Efficiency relates to the use of all inputs in producing any given output, including personal time and energy. Efficiency is a measurable concept that can be determined by determining the ratio of useful output to total input. It minimizes the waste of resources such as physical materials, energy and time, while successfully achieving the desired output.

Ports are no longer competitive based solely on port costs but when they can minimize the network’s costs, which are a function of sea, port/terminal and land interfaces, while offering reasonable quality and reliability for the transportation of freight throughout the maritime logistics journey. It is, therefore, within this context that one should assess seaport competitiveness that will steer port authorities in the most adequate undertaking
of strategic analysis. Those contributory factors most identified in the literature include geographical position, infrastructure/superstructure, risk and safety reputation, service quality and reliability, port management model, intermodal connectivity, productivity and efficiency levels and cargo handling charges, some originating from within the port itself. Commercial ports, which are some of the most important maritime transport infrastructures, should be able to measure their performance to ensure the efficient allocation of resources. For a valid and reliable measurement of performance and capacity, a method of analysis is needed that can provide the same results, even when performed with different entities. Therefore, there is a need for well-defined and thoroughly explained performance and capacity analysis techniques that leave no missing parts.

Ports have played an important role in global trade and the role has been redefined from the traditional role of handling cargos to one of the most crucial nodes in supply chains. Thanks to its advantages with cost saving and capacity utilization, shipping has always been considered as a primary means of international transport. Recently, the port industry has experienced a number of challenges and restructures due to changes in logistical environments, regional competition and environmental issues. Furthermore, the interests of different port stakeholders, i.e. port authorities, port users, service providers and related communities, in economic, social and environmental issues are sometimes in conflict. Therefore, port performance measurement is a challenging and complex task.

To exceed customer expectations, whose primary concern is to yield the highest value related to their business goals, a port must meet all customer goals and address concerns not only in port business but also in other service sectors. One way is through reducing waste and cycle time and improving the flow of right information and materials. Involving employees in identifying and eliminating process waste time can also assist port process development. Implementing the Lean culture within a port community is useful for port operations because it engages community actors to collaborate in environment improvement, and efficient energy management because the processes are interrelated. The objective of this research is to rigorously examine the implementation of Lean within the Umm Qasr Port, and to explore the impact of Lean on environment improvement and energy efficiency management. There has been no prior detailed study
on Umm Qasr Port performance nor has it been ranked as a highly efficient port. A case study using Lean is carried out with the primary goal of measuring and improving port performance, and raising Umm Qasr Port’s ranking to that of a highly efficient port.

Maximizing the capacity of a port is a complex issue to be considered by management. Even if adequate berth capacity is available to handle vessels’ loading and unloading, an efficient port depends on how efficiently the yard operation processes are performed, infrastructure of berths, equipment availability and hinterland connections. These issues linked with lengthy timetables, significant costs, and stakeholder groups with differing or even competing objectives are significant obstacles to providing additional port capacity in an expedient manner. Due to these constraints, methods to increase port capacity without significant investment in new resources are needed (Loyd et al., 2009).

Driven by development in economic activity, transport sector and port activities have grown significantly in recent decades. This growth is also the origin of pollution such as emission, noise and congestion. Traditionally, the efficiency of port activities has been measured in terms of money, time and reliability. Facing environmental pressure, social influence on transport is showing its importance. In developed countries, sustainable transport has attracted attention from both governments and transport operators. Relevant policies and measures are being introduced to promote intermodal transport, which is more environment-friendly.

Measuring port performance is an important tool for a Port Manager to understand whether the port is performing efficiently as reflected in the aforementioned statistics. However, there is more to improving port performance than just measuring it. The operational performance of a port is generally measured in terms of the speed with which a vessel is dispatched, the rate at which cargo is handled, and the duration that cargo stays in port prior to shipment or post discharge. However, a progressive port manager will also wish to know how extensively and intensively its assets are being utilized as well as how well the operations perform financially. Indicators to measure these performances are determined generally in relation to the tonnage of shipping calling at the port and of the volume of cargo handled since port services in the main are rendered to ships and cargo (Chung, 1993). A port authority implementing the Lean approach can use a combination of performance measurement tools and performance improvement methods,
which was one of the motivations of selecting this approach among other methodologies. Lean offers port operations a holistic approach that benefits other transferable port activities, including marine services, ship loading/unloading, storage and delivery operations, logistics, environment protection and energy management. The fragmented approaches may fail to take into account all related issues encompassing the ports, indicating that further studies are required to overcome the shortcomings. On the other hand, previous studies on port performance generally consider Port Performance Indicators (PPIs) from the port planner’ perspective with a focus on seaside operations. Further, PPIs measure operational performance by determining the ship operation, yard operation, storage operation and gate operation separately. In this regard, a new measure is suggested using the Lean approach to examine entire port operations taking into consideration customer demand as the core of port business.

While the concept of Lean manufacturing is frequently implemented in service providing companies, little research has rigorously looked into the implementation of Lean manufacturing in studies contexts other than production or the impact of Lean production on performance in these settings (Staats, B. & Upton, D., 2009). This research attempts to apply and examine the application of Lean in Port Performance Measurement, and Environment Protection within Ports and Energy Efficiency.

The results of a SERVQUAL test demonstrated that the process of vessel flow and cargo flow have the most negative impact on port performance. The Lean approach provides a significant method and tools for process development, taking into consideration customer value as first priority, which was a significant reason for selecting the Lean approach. The Lean approach focuses on maximizing the smooth flow and speed of products/services and provides powerful tools for analyzing process flow and delays at each step in the operation process. While adopting Lean, ports can be considered as centers in the separation of “value-added” from “non-value added” activity with sufficient tools to eliminate root causes of non-value added activities as well as providing a means for measuring and eliminating complexity cost (U.S. Environmental Protection Agency, 2009).
1.2. Research Scope

This research focuses on identifying:
- First, how port specific processes can be used to enhance a port’s asset utilization, yard areas, quays, and handling equipment.
- Second, how, at an advanced level, those port specific processes can interface with each other, including those of ship entrance, ship maneuvering, ship berthing, cargo clearance, and cargo unloading to create benefits for internal and external key port users. The focus will further be on environment and energy management benefits from the enhancement of port processes.

The Lean Approach implementation at the selected port could be used as a pilot scheme, which could help to pave the way for the instruction of a wider Enterprise Resource Planning (ERP) system serving all ports under the management of the port authority.

The research is aimed at providing a value stream mapping that will allow Umm Qasr Port’s services to improve the local business practices, business environment, and businesses strategy in addition to environment protection and energy management.

It is important to acknowledge that this research does not address operation bottlenecks and potential performance indirectly related to port operations such as hinterland connections.

1.3. Research Objectives

- **Main objective:** Examine the application of the Lean production theory to port operations, management and business process, enabling the port to perform efficiently, effectively, and in an environmentally friendly and energy efficient manner.

- **Secondary Objectives:**
  - Evaluating the service quality of the cargo handling process, environmental responsibility and energy management at the port of Umm Qasr.
  - Integrate the Lean process with environmental efforts and energy efficiency management, and measure their impact on port efficiency and environmental hazard reduction.
1.4. Methodology
Since the main focus of the research is measuring the efficiency of port processes by implementing Lean as a process improvement approach, a qualitative and quantitative investigation was performed of entire port processes. Other relevant aspects such as a SERVQUAL test to identify and discover the real causes of low efficiency to identify solutions. In order to apply Lean implementation methodology to port processes in different areas and collect research data, several approaches have been carried out during the research work:

- Extensive and detailed literature review into Lean implementation in the service sector, environmental effort and energy management.

- Before selecting a specific Lean method and tools, data collection was carried out by implementing the “stand in the circle” (Go to Gemba) tool to collect real data to identify the current value stream map and identify waste that should be eliminated in order to achieve a significant level of customer satisfaction. Visits were made to Umm Qasr Port to collect the port performance measurement data required to examine the current port performance level from which an initial assessment for port processes was made. In the Lean concept, go to Gemba means the actual place where service is being provided. Therefore, this practice helped the researcher to gather actual first-hand data on what is happening in the port of Umm Qasr. The observations from the go to Gemba practice resulted in identifying 30 quality elements. The next step was to operationalize those 30 quality elements to be the bases of SERVQUAL test questions. Data collected from this questionnaire was analyzed using SPSS software. The main aim was not to compare port services with other ports but rather to try to measure the service quality of this specific port and customer satisfaction from the customers’ perspective because Lean approach focuses on specific process improvement. Service quality should be defined in the context of the port sector to get a clearer picture of the quality elements that should be included in the questionnaire. In this research, the ROPMEE model was developed by the researcher to measure service quality in the cargo delivery process in the Port of Umm Qasr as it covers all the functional and non-functional areas in the cargo delivery process compared to other quality dimensions. Applying the ROPMEE model by taking the customers’ perception and expectation would pinpoint the most challenging quality
dimension of port services. Based on the findings, the proper Lean method need to be selected to tackle this challenging quality dimension in order to achieve continuous process improvement. Value stream mapping method was applied on the processes of Umm Qasr Port because the findings of SERVQUAL test revealed that this port is facing serious challenges in port service processes. During the mapping of current value steam for different processes, several wastes were identified and need to be eliminated by drawing the future value stream map. As a result of the value stream mapping, the impact of Lean implementation on service cost, service time, environment and energy consumption was measured.

- Environment protection efforts and processes were examined by applying Lean tools in terms of implementation plans and activities, operation-environment associated activities, environment initiatives, energy management and waste treatment. A further analysis was carried out during the period March-October 2016 using the Carbon Footprint Analysis (CFA) and ranking the factors using the Gray Relational Analysis (GRA) in order to quantify the benefits of implementing Lean approach.

- Interviews were conducted with port customers to identify non-value adding activities and the customer satisfaction level was measured by applying a SERVQUAL test. These interactions were examined on how port community is prepared for such management transformation and how they are expected to react.

- Port Regulations and instructions were studied in detail in order to determine whether the current management approach is subject to change if required since Lean approach is working culture changing.

1.5. Umm Qasr Port

Basra is Iraq’s only international port—an important strategic center for the country and its interactions with the world. It is also of vital economic importance in securing a large portion of Iraq’s import needs and a key port for exporting crude oil and other Iraqi products. Port activity and maritime transport have therefore been important in Iraq over the years, particularly in the 1970s, and Basra has become the center of economic activities associated with import and export. Port activities are funded and managed entirely by the state through the General Company for Iraqi Ports. Currently, Iraq has
four commercial ports and two platforms to export oil. There are 48 commercial port berths with a capacity of 17.5 million tons annually, of which 43 are currently operational with a capacity of 15.90 million tons annually. Iraqi ports face stiff competition from the ports of nearby countries (the United Arab Emirates and Qatar, for example) and neighboring countries (Kuwait, Jordan, Syria, Saudi Arabia, and Iran). These ports have made significant progress over the past two decades while performance and efficiency in Iraqi ports have declined as the result of economic sanctions and wars. Overall, Iraqi ports have experienced no noticeable improvement domestically or internationally. Umm Qasr Port is the main port for general cargo, project cargo, RoRo, and containers in Iraq and is located south of Basra city. The port is connected to the hinterland by developed road and rail inland network. UQP predominantly serves hinterland areas of the Basra region. Umm Qasr Port handles multiple types of cargo, such as cars, pipes and steel products, passengers, general cargo, cement, sugar, rice, wheat, and containers. The port consists of 23 operational berths and three berths under construction divided into North Port and South Port. Cargo handling operations in the port of Umm Qasr are carried out by one of four cargo handlers namely: port authority, ship agent, local stevedores or international terminal operator according to the agreement with port authority.

1.6. Research Structure

To summarize the research, Figure 1 illustrates how the research was structured using Lean to improve operations processes in Umm Qasr Port and measure the impact of Lean implementation on the three pillars.
This research emphasized on the process improvement for ship operations and cargo operations in the port of Umm Qasr justifies the selection of Lean methods and tools. Mainly, other methodologies focus on measuring port performance in terms of efficiency, effectiveness and production that is not the objectives of this research. Efficiency has
been noted as ‘doing things right’ while effectiveness is ‘doing the right things’. The right things are those that are important to the customer.

Chapter two evaluates the quality elements of provided services by the port and highlights the impact of each element on customer perception and expectation by using SERVQUAL test.

2. Chapter Two: Process Improvement and Port Performance Measurement

2.1. Literature Review

Ports have played an important role in global trade and this role has been redefined from the traditional role of handling cargo to one of the most crucial nodes in the supply chain. Thanks to its advantages of cost saving and capacity utilization, shipping has always been considered as the primary means of international transport. Recently, the port industry has experienced a number of challenges and restructures due to changes in logistical environments, regional competition and environmental issues. Furthermore, the interests of different port stakeholders, i.e. port authorities, port users, service providers and related communities, in economic, social and environmental issues are sometimes in conflict. Therefore, port performance measurement is a challenging and complex task.

Performance understanding is a fundamental concept to any service and it begins by evaluating achievements against set objectives and goals, and observing and evaluating competitor progress. A port, like any other business, needs to evaluate how much business is being generated, the quality and delivery of services, and customer satisfaction, including customer feedback. Ports are not immune to public scrutiny and it is only by feedback and comparison that performance can be examined. Ports generally are, however, sophisticated businesses with various inputs and outputs sources that allow a direct comparison among homogeneous ports apparently difficult to make (Valentine and Gray, 2002). Performance has been defined by Mentzer and Konrad (1991) as an evaluation of efficiency and effectiveness in the accomplishment of a given activity where the assessment is carried out in relation to how well the objectives have been met. UNCTAD (1999) suggests two categories of port performance indicators: macro performance indicators, quantifying aggregate port impacts on economic processes, and micro performance indicators assessing input/output ratio measurements of port
operations. Like any other industry, the port industry evaluates its efficiency and effectiveness by measuring performance. Port Performance evaluation is a need for the economic activity development and the previous studies suggests various definitions of port performance (Marlow & Casaca, 2003).

Traditionally, calculating cargo-handling productivity at berth has been used to evaluate the performance of ports (Bendall and Stent, 1987; Tabernacle, 1995), through using the measurement of a single productivity indicator (De Monie, 1987). Other way of performance measurement is by comparison of actual throughput over a specific period with optimal throughput over the same time (Talley, 1988).

The early era of container port performance studies focused mostly on investigating seaside operational efficiency, productivity and utilization. The studies were particularly targeted at single-port level (Talley, 1994), country level (Park and De, 2004) and international level (Tongzon, 1995). These studies, however, failed to link quayside operations and landside systems.

Compared to port efficiency and productivity studies, a port effectiveness-focused approach has not been much attracted until middle of the 2000s. In port/terminal operations, effectiveness may denote that desired results (i.e. service) are delivered to port stakeholders (i.e. customers, government, regulators, providers and other entities) who may have different performance objectives. Namely, different stakeholders’ perspectives should measure port effectiveness. Brooks (2006) noted the importance of combining efficiency research with effectiveness for port performance measurement. Brooks and Pallis (2008) developed a conceptual port reform performance framework integrating various relevant port performance indicators under existing port governance models. Brooks et al. (2011) investigated port users’ (three user groups of carriers, cargo interests and supplier of services) needs with regard to which criteria are important to them in terms of the services received and how they evaluate port effectiveness. Brooks and Schellinck (2013) examined the importance-performance gap based on divergence between effective performance and user expectations and looked for guidance on how to use the data collected from the users in identifying and prioritizing investment in improvement efforts. With changing environments affecting the role of ports, studies of port performance measurement have been conducted by focusing on port centric logistics
as moderators and their integration in the supply chain (Marlow and Paixão Casaca 2003, Bichou and Gray 2004). Over time, the concept of the ports has been redefined in terms of their function, geographical scope and activities (Notteboom and Winkelmans, 2001; Paixão and Marlow, 2003). Hence, ports have continuously been adapted to the evolutionary changing environment to sustain themselves in highly competitive environments. Numerous studies have introduced conceptual frameworks and dealt with port evolutionary changes such as supply chain integration, Lean/agile perspectives, customer-oriented practices, and value-added activities (Marlow and Paixão Casaca, 2003; Bichou and Gray 2004; Bichou, 2006; Langen et al., 2007; Panayides and Song, 2009; Woo et al., 2011; Brooks and Schellinck, 2013; Woo et al., 2013). However, these studies suggest either conceptualizing the framework without empirical research or validating correlations between the issues and port performance on partial dimensions. Any failure or unreliability of port service can have huge impacts on the smooth movement of these flows in the further stages of the supply chain and result in unhappy port customers (shipping lines and cargo owners). This role of ports in supply chains is increasingly seen in management practice and not only in academic literature. Many ports are progressively perceived in the supply chains of their customers as inseparable and integrated nodes. Therefore, well-developed research, conducted on ports in the current literature includes the measurement of port efficiency and port selection (port choice) in the logistics and supply chain context. Although the topic of port service quality measurement has been addressed in the research for quite some time, there has never been a Lean approach involvement in the definition of the concept of quality and its impact associated factors within port business. Essentially, customer satisfaction is the condition that is derived when customers’ experience with the service meets or surpasses their expectations. In most literature on port business and more specifically marketing strategy, satisfaction is introduced as the global assessment of relationship fulfillment by the firm (Dwyer and Oh 1987) or the positively influenced state resulting from the evaluation of a firm’s business relationship (Farrelly and Quester 2005, Gaski and Nevin 1985). Thus, customer satisfaction is one of most significant factors for explaining any kind of relationship among business participants (Sanzo, Santos, Vazquez and Alvarez 2003). Oliver (1997) stated that satisfaction is ‘the consumer’s fulfillment response, a
judgment that a service or product attribute, or the service or product itself, provided (or is providing) a satisfactory level of consumption-related fulfillment’.

Generally speaking, customer satisfaction is related to the quality of products or services provided to the customer in a positive manner, e.g. the level of customer satisfaction will be enhanced along with the increased perceived level of product or service quality; in other words, customer satisfaction is an outcome of service quality. Considerable research has examined the relationship between service quality and customer satisfaction in a number of service sectors and has confirmed this positive relationship (for example, see Brady and Robertson 2001, Parasuraman et al. 1994, Cronin and Taylor 1994) despite some conflicting evidence (for example, see Rosen and Suprenant 1998). A few studies in the transport sector have focused on the relationship between service quality and customer satisfaction in the aviation industry (for example, see Anderson, Baggett and Widener 2009) and high-speed railway (for instance, see Cao and Chen 2011), and found that this relationship is positive and significant. Nevertheless, research on this relationship in the maritime sector, especially in the context of ports, is scant and deserves further investigation.

Most literature on maritime-related issues focuses on carrier concerns and selection of port rather than on the detailed measurement of service quality. Among the relevant research, Ugboma et al (2004) pointed out that all five Service quality dimensions were valid. Meanwhile, three dimensions were found by Lopez and Poole (1998) that contributed to the port services quality, namely, ‘timeliness’, ‘efficiency’ and ‘security’. Ha (2003) defined a port service quality factors group including ‘port turnaround time’, ‘information availability of port-related activities’, ‘facilities available’, ‘port location’, ‘port management’, ‘customer convenience’ and ‘port costs’. Pantouvakis (2006) developed six factors of service quality, namely, ‘services’, ‘information’, ‘security and safety’, ‘cleanliness’, ‘parking facilities’ and ‘guidance-communication’, that are very specific to passenger ports operations. Cho et al (2010) formulated a separate port service quality measurement tool, comprising ‘exogenous quality’, ‘endogenous quality’ and ‘relational quality’. However, there seems to be little convergence so far on what factors systematically constitute port service quality.
In addition, these studies ignore a critical dimension, ‘social responsibility’, which can improve or negatively impact the reputation of organizations and hence the perception of their service quality. This is particularly significant in the context of the large number of ports around the world now attempting green initiatives implementation. Further, the important influence of service quality, particularly on customer satisfaction, in the port business is not a topic that has been empirically well researched. Port performance measurement development requires the implementation of a two-stage integration process, internal and external. It is, therefore, proposed that a two-tier measurement of port performance indicators also be developed. The new port measurement indicators besides recognizing quantitative aspects will focus on qualitative issues as they bring increasing visibility within the port environment and along the transport chain, enhancing the integration of all supply chain logistics components. Qualitative performance indicators are at the heart of Lean ports and, consequently, of port networking (Marlow, P. & Casaca P., 2003).

Loyd et al (2009) implemented Lean tools on unloading operations between major ships and small barges at the Port of Mobile, Alabama and found that the Port has experienced positive results that can directly provide additional capacity, including the ability to handle more revenue railcars (30% increase) and a reduction in barge loading times (125% improvement), barge unloading times (70% improvement), ship unloading times (26% improvement), ship loading times (44% improvement), and train car dumping times (100% improvement).

Measuring port performance is an important tool for a Port Manager to understand whether the port is performing efficiently as reflected in the aforementioned statistics. However, there is more to improving port performance than just measuring it. A port authority implementing the Lean approach can use a combination of performance measurement tools and performance improvement methods and keep the researcher motivated in his decision to use this approach among other methodologies. Lean offers port operations a holistic and proper approach that benefits other transferable port activities, including marine services, ship loading/unloading, storage and delivery operations, logistics, environment protection and energy management.
While the concepts of Lean production are frequently applied in service organizations, little work has rigorously examined the implementation of Lean production in contexts other than manufacturing or the impact of Lean production on performance in these settings (Staats, B. & Upton, D., 2009). This research attempts to apply and examine the application of Lean in Port performance measurement, and environment protection within the port area and energy efficiency.

The literature tends to focus on limited dimensions or specific areas of the port/terminal and not on the port as a whole. Despite various studies on service quality in different sectors and its relationship with customer variables in other sectors, research on systematically defining and eliminating non-value-added activities, as well as the measurement of customer demand as part of service quality is scant and requires further investigation.

2.2. Techniques for Measuring Process Improvement and Port Performance

Numerous methodologies have been applied to measuring port performance. These include a heuristic approach to identify performance indicators (Brooks, 2006), technical and economic efficient equations (Talley, 2006), parametric or econometric approaches such as a cost or a production frontier function (Gonzalez and Trujillo, 2005), a stochastic frontier analysis (SFA) (Cullinane et al., 2002); a non-parametric approach such as data envelopment analysis (DEA) (Cullinane and Wang, 2006); a confirmatory fact analysis (CFAS) and structural equation modeling (SEM) (Woo et al., 2011; Woo et al., 2013); and an importance-performance gap to investigate perception difference between ports and port users on PPIs (Brooks and Schellinck, 2013).

In recent years, significant progress has been made concerning the measurement of efficiency in relation to productive activities. In this vein, two complex yet more appropriately holistic methodologies, Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA), have been increasingly utilized to analyze port production and performance (Culliane et al, 2004). The complexity of different seaport operations often results in difficulties in using analytical tools as a method of investigation. In such a situation, computer simulation provides a powerful tool to analyze port performance (Tahar, R. & Hussain, K., 2000). Simulation has been widely used and applied to the
planning and management of the port system (Borovits and Ein-Dor, 1990 & Gambardella et al., 1998).

2.2.1. Port Performance Indicators (PPIs)

Commercial ports, which are some of the most important maritime transport infrastructures, should be able to measure their performance to ensure the efficient allocation of resources.

UNCTAD discussed PPIs in a classic monograph on port performance indicators such as berth occupancy ratio, charges per ton of cargo, and equipment cost per ton of cargo as well as focusing on the productivity of terminals (UNCTAD, 1976). Performance measurement of ports is more complicated as is illustrated by the fact that the port is a cluster of economic activities (De Langen, 2004). Tongzon (1995) suggested that attention should be paid to this information when developing port reforms aimed at improving port performance methods as this gives a clear distinction between port effectiveness and efficiency. Consequently, port performance indicators have been classified by UNCTAD (1976) into two broad categories, financial (tonnage worked, berth occupancy revenue per ton of cargo, cargo handling revenue per ton of cargo, labor expenditure, capital equipment expenditure per ton of cargo, contribution per ton of cargo and total contribution) and operational (arrival date, waiting time, service time, turn-around time, and tonnage per ship).

Throughput volume is the most widely used PPI for measuring port performance and it ranked according to the handled volume of cargo. These figures of cargo volumes are normally published in port media and on port authority websites. Throughput growth is considered as proof of improvement in port performance. Although cargo volume figures are widely used as a performance indicator, there are some limitations of throughput as PPI because it does not express the economic impact of the port and global trade affects it.
There are many classifications of performance measurement of container terminals. Kisi et al. (1999) classify the port performance indicators into four levels as shown in Figure 2.

Thomas and Monie (2000) also suggested that performance measures could be divided into four categories. These are production, productivity, and utilization and service measures as shown in Figure 3.
ESPO (European Sea Ports Organization) has taken the initiative of establishing a culture of performance measurement in various European ports with the PPRISM (Port Performance Indicators: Selection and Measurement) project. The PPRISM project intends to introduce a set of feasible and relevant port performance indicators for the EU port system as shown in the Figure 4. These indicators enable EU ports to assess, measure and communicate the significant impact of the European port system on the economy, society and environment (ESPO, 2012).
Figure 4. List of port performance indicators selected by the ESPO study

Source: European Sea Ports Organization ESPO, 2012

Obviously, data needed for the calculation of the aforementioned port performance indicators should be available be collected annually and obtained exclusively from port
authorities. The absence of significant data justifies the adoption and use of another methodological approach for measuring port performance indicators.

2.2.2. Business Process Simulation Software- Like Arena

Business process simulation programs are powerful and effective tools for cost-benefit analysis of projects involving costs for eminent investment, research to develop the functionality of an existing system, and the measurement of efficiency and effectiveness (Uğurlu et al, 2014). Those programs do not demand huge investment costs and enable organization management to establish advanced planning and identify problems that may happen in the future. In practice, various studies have been carried out on the design and re-design of handling equipment, facilities, information systems and the improvement of logistics control software.

Computer-based instruments such as simulation programs provide the opportunity to mimic port operations and to measure the behavior and performance of the system under various operating conditions and to systematically diversify these experimental factors for the purpose of studying the behavior of the system entirely. Recent simulation modeling advances, software with optimized ease-of-use and, to a greater extent, influential microcomputers indicate that a computerized simulation program of port operation within a container terminal can become a powerful tool for decision-making in areas such as the layout of port facilities and selection of proper equipment.

A model designed by a user is the first requirement in the computer simulation program that provides the behaviors/functions or the key characteristics of the chosen abstract or physical system or process to the user. The computer simulation model could anticipate the advantages and disadvantages of real system behavior. Business process simulation programs are utilized in almost every sector or field, including scientific, engineering, and technological disciplines. In recent decades, Business process simulation programs have been implemented in a broad variety of applications. Currently, the methods are used in the design of new programs, existing systems analysis, training for all sorts of activities, and as an interactional entertainment form (Smith, 1999).

Port operations and management, as part of the maritime industry, is a costly business so any failure or deficiency in the system may result in high cost. Therefore, business process simulation models have a significant presence in port operations and
management. Many different techniques can be used to identify whether the port is managed efficiently or not as the efficiency of ports can differ between countries and regions. There are many methods to determine port efficiency such as: multi-criteria decision-making methods, analytical modeling methods, and simulation modeling methods.

The most significant aspect of system modeling is to identify and define the criteria of efficiency because port terminals are very sophisticated and can be used for multiple functions. For example, efficiency criteria for a port that handles dry bulk cargo or general cargo can be defined as the number of ships handled per day/week. On the other hand, liquid bulk cargo requires more value-added than general cargo, which makes many vessels pay demurrage and suffer delays due to a lack of port facilities. Efficiency criteria for oil terminals that were designed for handling dangerous and valuable oil products could be focused on safe and fast cargo handling. Hence, analytical methods or simulation techniques to evaluate port efficiency and cargo handling capacity should model a port.

Generally, simulation techniques have been used in the maritime industry for marine accident modeling, shipbuilding process modeling, and evaluating the efficiency of port operations (Goerlandt & Kujala 2011; Hirsch et al., 1998; Kim et al., 2004; Lee et al., 2003). Numerous scholars have carried out studies on port modeling. Bressman et al. (1978) used a computer simulation to integrate the uncertainty of specific key suppositions into fiscal planning and an investment proposal assessment. The simulation was designed to include annual cash inflows and outflows for the future and to evaluate a project in terms of overall feasibility. A numerical simulation model has been used to determine the impact of randomized waves, and irregular winds and currents on an oil tanker as single point moored. This study separately solved the mooring line dynamics and rigid-body and provided an equation of motions as computer model (Wichers, 1988).

Another approach was developed by Collier (1980), considering the port as an integrated system in his research. In the research, port system elements were specified as cargo arrival or dispatch, cargo storage under proper conditions, terminal handling facilities and vessel handling arrangements. Some supportive facilities are needed to operate these elements efficiently such as engineering, transportation, workforce, resource allocation
and documentation procedures. As a result of this research, rigorous data collection methods required analyzing the port system and, subsequently, designing defined models to test the impact of system parameter variation.

Demirci (2003) examined bottleneck points in overloading conditions by implementing a simulation-modeling solution. According to this study, terminal trucks that are used for loading/unloading generated the most crucial bottleneck points. Therefore, it was necessary to apply an investment strategy to the model for load balancing of the terminal at this point. Consequently, a computer simulation program was used to evaluate improvements by increasing port resources within economic viability. Yeo et al. (2007) applied Awesim simulation modeling to predict the traffic concentration at Busan port that occurred in 2011. In the study, Busan harbor data over a 10-year period (1993-2002) was used. The results of this study highlighted the necessity to reallocate terminal functions in pier number two, expanding the superstructure capacity of the container terminals, and recommended the cancellation of one of the anchorage areas.

Steenken et al. (2004) suggested three simulation models in container terminals: strategical, operational and tactical simulation. Strategical simulation functions to adjust the layout of a terminal and decide on handling equipment that produces high-performance levels and low operational costs. The main purpose of operational simulation is to examine alternative methods for optimization in a simulation model in real terminal planning and control systems before they are implemented. The third model, tactical simulation, explains the simulation integration into the system of a terminal’s operation, which means that the simulation is undertaken parallel to the real operation of the terminal. Hartmann (2004) explained simulation programs as instruments to assess a container terminal’s dynamic processes that offer analyzing and generating statistics such as average waiting time, average productivity, and average number of box moves in the stacking yard.

Many port managers and researchers have applied an Arena-based simulation models to evaluate terminal operations efficiency and to highlight future development directions of operational management and the terminal configuration. Such simulation models enable the management to analyze a number of pre-defined criteria of port performance such as average waiting time of the resources, average terminal resource utilization, and average
productivity to identify potential operational area bottlenecks, specifically the quay cranes, the transportation system and the storage yard.

To simulate port operations for the purpose of measuring performance, a thorough awareness and understanding all the factors involved is required, without this understanding and awareness a business process simulation cannot be created. The port operation department of the selected port has an insufficient understanding of the way that some physical systems operate, so they do not have adequate and sufficient data to create a mathematical model.

2.2.3. Data Envelopment Analysis (DEA)

Data Envelopment Analysis (DEA) is an established proper statistical method that measures the relational efficiencies of organizations where unsophisticated efficiency measures are not easy to obtain (Farrell 1957; Charnes et al 1978). The attractive feature of DEA is its capability of dealing with multiple inputs and outputs. The units in any DEA evaluation are mostly independent and homogeneous units with the same function performed. It is used to the highest degree where there are a great number of units providing an 'identical' service in relative isolation (Szczepura et al 1992). The DEA technique was first evolved as a way of assessing service units by Charnes et al. (1978). Since then, the model has been further developed. DEA research has been pioneered in the UK by the Warwick Business School, considered one of the leading research institutions specializing in this domain. DEA has been successfully utilized in different sectors such as local government authorities, courts, airports, bank branches and hospitals’ general medical practices to measure efficiency where there are multiple units of inputs and outputs. DEA application to the port sector would therefore seem to be ideal. As far as the researcher is aware there have been a number of studies using DEA within the seaports industry. Roll and Hayuth (1993) stated that DEA is the most appropriate tool for assessing port efficiency, although they have only implemented it hypothetically.

Various other attempts have succeeded in using the measurement of productivity based upon output per berth (Frankel 1991), and output per worker (DeMonie 1987) whilst production functions have been used by others, (Kim and Sachish 1986, DeNeufville and Tsunokawa (1981). Gillen and Lall (1997) searched airport terminals and selected two
outputs, pounds of cargo and number of passengers. They selected six inputs, number of gates, number of employees, number of belts for baggage collection, runways, terminal area and number of public parking places. The results indicated that the factor with the most significant overall effect on efficiency is the number of gates. In terms of seaports, gates where the loading of the cargo is facilitated could correspond to loading/unloading cranes and runways to jetty.

Basically, we can measure efficiency as a ratio of output to input assuming that only one output is produced. However, from multiple inputs as most organizations generate multiple outputs as variables, a weighting for each variable needs to be given to create a more accurate result. Efficiency then gets to resemble the summation of weighted outputs over the summation of weighted inputs. As the technique of weighting can be biased towards one specific outcome, the DEA method permits for each weighted input and output to be perceived in its most favorable light.

The number of variable factors inserted into the formula causes more of a discriminatory power of DEA, which means that a greater number of variables entered into the formula may result in a lack of focus on a particularly significant piece of data. Therefore, Szczepura et al (1992) indicated that the number of variables should be as low as possible.

2.3. Service Quality of Umm Qasr Port

It should be noted that traffic forecasting and performance evaluation facts for Iraq’s ports is greatly hampered by Iraq’s specific framework conditions. Owing to the wars and economic sanctions Iraq has gone through in recent decades, very few lasting trade and transport patterns exist that can be used as starting points to predict Iraq’s future trade, transport flows and performance measurement (GCPI, 2015).

As a consequence, few trade and transport figures of the recent past are available. In particular, to the researcher’s knowledge, there are no official statistics on the performance indicator development of Iraq’s general cargo or container handling efficiency. However, even if the historical development of these figures was available, it might be questionable to what extent they can be used to predict future developments and evaluate the efficiency of the port in light of Iraq’s recent political and economic changes. Unlike most other countries, an increase in the general cargo traffic in Iraq’s
ports will most likely be driven not only by an improving economic situation, but also by a shift in the share of cargo from overland to oversea transport, provided that sufficient capacities will be available in Iraq’s seaports. Therefore, this research also needs to take into account the effects of changing transport flows when evaluating the performance of a selected port.

Owing to the absence of reliable quantitative data on the structure of Iraq’s trade and transport flows in recent years, a scenario based on the real situation data collection has been elaborated by the researcher, which takes into account his observation customer perception and expectation.

Umm Qasr Port is the main port for general cargo, project cargo, RoRo, and containers in Iraq and is located south of Basra city. The port is connected to the hinterland by a developed road and rail inland network. The port facilities stretch about 5.2km along the river and an excavated tributary arm extends towards the northwest. The total facilities, divided between a north and south port, consist of 22 berths and 2 RoRo-berths. The port facilities in Umm Qasr comprise four different walled and fenced compounds. The two principle areas are referred to as the “South Port” and the “North Port” The south port area is located along the Marine Channel.

The north port area continues inside a widened and dredged manmade basin off the Marine Channel and is located northwest of the south port. The two port areas handle containers, general cargo, grain and other bulk as well as sugar and vegetable oil. The current operation in the Port is characterized by operations and administrative procedures, where most data and information exchange is carried out on paper in offices at multiple locations inside the port operations area. This results in operational delays and in private individuals and vehicles entering the port operations area. Trucks are currently allowed into the operations area before the cargo has been released (by Customs, Port, and Shipping lines). In addition, import cargo is subject to customs inspection inside the operations area after being loaded onto trucks. This results in many trucks and persons (agents, customs officers, etc.) inside the operations area causing safety and security risks as well as obstructing efficient cargo and equipment flow. The Port has over the last years acquired new Reach Stackers from Kalmar; Container Ship To Shore Gantry Cranes (STS cranes) from ZPMC; and Mobile Harbor Cranes from Liebheer. However, it still
lacks sufficient and appropriate cargo handling equipment to provide a satisfactory level of service. This is especially true for vessel operation, where shipping lines choose to utilize their vessels’ own vessel gear (ship cranes) and their own trucks.

With an increasing cargo volume demand in the Port and the need to increase capacity, the port will, in the short term, need to implement new operational and administrative practices. This will require relocating administrative functions (currently carried out in offices within the operational areas) to an area outside, as well as the introduction of new cargo handling equipment (Reach Stackers, Trucks, Cranes and possible RTGs) to increase container storage capacity. The introduction at this point of a Port IT system solution of standardized design compatible with new operations and administrative practices would be opportune. Improved systems and processes combined with modified organizational setups are prerequisites for the introduction of new cargo handling operations and equipment. The combined effects of these measures will result in a necessary increase in the capacity, which the increased traffic demand requires.

The calculation of berth capacity is understood to distinguish between technical and operational capacity. The technical capacity is the maximum capacity of the respective berth determined by the number of cranes deployed, type of vessel, vessel stowage arrangements, and working days per year. The operational capacity is defined as the technical capacity multiplied by adequate berth utilization (HPC, 2012). The congestion point defines this adequate berth utilization when the terminal loses the capability to berth vessels at any given time.

The objective of each terminal operator is to avoid berth congestion, i.e. to avoid the so-called “berth congestion point”, when the terminal loses its capability to berth vessels as they arrive and waiting times of ships are the consequence. Congestion usually begins when a targeted berth occupancy rate, calculated on annually expected throughput and ship calls is exceeded, and, if countermeasures are not taken in time, the queuing of ships rapidly soars. Adequate berth utilization increases with the number of berths. Under the assumption of random ship arrivals and no priority berthing system in force, the following berth utilizations have been proven from long time experience to be realistic (UNCTAD, 1985):

- Single berth operation: 30%

26
Two berths with at least 500m berth length: 55%
Three berths: 65%
Four berths and above 70%

It must be understood that this berth utilization rate is not primarily a technical limitation, but caused by marketing and economic considerations. Longer waiting times of vessels make the terminal (and/or port) less attractive, as additional costs for the shipping lines are caused, which either react with the measure to impose a surcharge for the respective port or to change the terminal. As a consequence, the terminal, its customers and the economy as a whole are losers. In order to determine present and future terminal berth, crane, storage and equipment performance as well as the associated activities, this research intends to evaluate the current performance and process efficiency by using Lean approach in order to fill-in the gap.

In today’s computerized world where data and information can be exchanged within seconds and everybody is heading for just-in-time solutions, intelligent IT systems are of particular importance for the performance and competitiveness of seaport container terminals. Without proper IT solutions, it is hardly possible to maintain an overview of the terminal’s equipment and storage situation, and it is completely impossible to use the available storage and equipment capacities in an efficient way. Based on the available overview, the port collects most of the information manually by using traditional means of communications that have a negative impact on port efficiency.

Many IT systems for container terminals of different size and operation are available on the market. These called terminal operating systems (TOS) mainly differ in the functionalities provided. In general, a TOS should cover the following functionalities:

- Electronic Data Interchange for the submission of stowage plan, manifest and other relevant cargo data to be submitted to the terminal at least 24 hours before arrival of a vessel;
- Terminal planning and control system with a visual graphic display of berth and yard occupation;
- System development possibilities for container depot and customs interface;
- Management and administrative information systems.
However, the exact configurations of these functionalities differ among TOS providers. Often, IT systems are even customized according to the specific needs and operations of individual terminals in order to get the best out of the terminal system. Determining which functionalities are essential and how they should be realized usually requires comprehensive expert analysis.

2.4. SERVQUAL Method

2.4.1. Introduction

To exceed the expectations of customers, whose primary concern is to yield the highest value related to their business goals, a port must meet all customer goals and address concerns not only in port business but also in other service sectors. One means is through improving the flow of right materials and information and reducing waste and cycle time. A port, like any other business, needs to evaluate how much business is being generated, the quality and delivery of services, and customer satisfaction, including customer feedback.

A port or terminal is just as much a business as any factory, supermarket, bank or professional service provider. And just like any other business, it needs to know how much business it is doing, how well it is carrying it out, and what its customers think of it. In other words, it must measure its performance. It has been well said that measurement of performance is the first step towards successful management of any business venture — without performance measures and data, managers are navigating blindly, and cannot know where their business is or where it is going.

Finally, as well as using performance measures to indicate how much work, how efficiently and how intensively the organization performs, it is essential to measure the quality of service provided to its customers. So the fourth category of performance measures is service measures. They are really ways of finding out how the customer views the organization’s performance. A variety of service measures can be used by the terminal to discover how satisfied its customers (ship operators, shippers and receivers of cargo, and transport operators) are with the service provided, and what quality of service is being offered to them.
The terminal may be the only container terminal in the area, and its management might feel that it has a captive customer base, but it must always remember that ship operators can still decide not to call if they feel they might receive better service elsewhere. Shippers and importers will then have to find some other means of transporting their goods — almost certainly at higher cost. So, as to other businesses, service measures are extremely important to ports. This customer satisfaction level has become a challenge to port activities since resources are limited within the port premises. Further, poor cargo handling processes result in bottlenecks at the end of the cargo chain, and directly affect the logistics performance of the port. These challenges negatively affect the quality of the service offered to all stakeholders of the Port of Umm Qasr who are involved in activities within the Port premises. Therefore, port customer perceptions/views were taken into consideration in evaluating the service quality of the cargo handling process, environmental responsibility and energy management at the port of Umm Qasr.

2.4.2. SERVQUAL Instrument

According to Asubonteng et al., (1996), as a result of strong competition and the aggression of environmental factors, service quality has become a fundamental marketing strategy for service providing organizations. This shows how significant improving the quality of service is to organizations for their continuation and development since it could assist them in confronting the difficulties they face in competitive markets. This suggests that service providing companies are compelled to deliver excellent quality services to their clients to maintain a sustainable competitive advantage. There is, however, a requirement for these companies to realize what service quality is for the purpose of attaining their objectives.

In service providing literature, Eshghi et al., (2008) identify service quality in general as the overall evaluation of a service by the organization’s customers. Asubonteng et al., (1996) define service quality as the satisfactory level to which a service satisfies customer’s expectations. Parasuraman et al., (1985) define service quality as “the discrepancy between consumers’ perceptions of services offered by a particular firm and their expectations about firms offering such services”. The customers will consider the
quality of service low when perceived service is below expectation and satisfactory if perceived as meeting or exceeding their expectation.

SERVQUAL is a method that has been used to measure the quality of services since the 1980’s. Parasuraman et al. (1985, 1988, and 1991) developed the SERVQUAL model, containing five quality dimensions and 22 quality elements, which has subsequently been tested and accepted in many service industries. Essentially, SERVQUAL is used to measure the difference between a customer’s perception and expectations about the services they experience. Therefore, the gap between perception and expectation is used to analyze the customer satisfaction level across certain quality elements or quality dimensions.

Despite the applications of the SERVQUAL model, various scholars have criticized it. Cronin and Taylor (1992) proposed a model called SERVPERF, which has eliminated the expectation component that exists in the SERVQUAL model. Carman (1990) stated that SERVQUAL has a lack of dimension stability as it is limited to the few industries identified by Parasuraman et al (1985, 1988). Meanwhile Ugboma et al (2004) found that all SERVQUAL dimensions were valid. Most recent studies highlight that SERVQUAL is not a universal tool to measure service quality in certain contexts, as an example in B2B services (Benazić and Došen 2012), banking (Guo, Duff and Hair 2008), and supply chains (Seth, Deshmukh and Vrat 2006). Meanwhile, various authors found that SERVQUAL dimensions are either too numerous or too few for specific contexts.

2.4.3. Service quality in Maritime transport

Competition in the transport sector has been increasing over the past few decades due to organizations attempting to improve the quality of services to achieve competitive advantage in the industry (Cotham et al. 1969). As Thai (2008) suggests, the quality of service delivery is strategically important to any kind of organization in order to survive in the industry. He adds that there is no universally accepted method or measure for quantifying the service quality experienced by customers, as the quality is highly dependent on the perceptions of the customers.

Table 1 summarizes studies carried out in the context of maritime-related service quality in chronological order to indicate the evolution of service quality thinking and models.
The table also indicates the number of dimensions used and the variety of quality dimensions used in those studies. Different studies have adopted different quality dimensions that have been introduced by different scholars who have tried to devise universal quality dimensions for the maritime sector. Table 1 illustrates the inconsistency in the use of quality dimensions in different studies as the SERVQUAL quality dimensions have failed to be represented in the maritime service quality context.

Table 1: Summary of literature in maritime sector

<table>
<thead>
<tr>
<th>Year</th>
<th>Author</th>
<th>No. of Dimensions</th>
<th>Quality dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>Pearson</td>
<td>5</td>
<td>Flexibility / First on the quay / Speed of transit / Reliability / Regularity</td>
</tr>
<tr>
<td>1985</td>
<td>Slack</td>
<td>6</td>
<td>Size of port / Port equipment / Proximity of port / Port security / Port charges / Congestion</td>
</tr>
<tr>
<td>1985, 1990</td>
<td>Brooks</td>
<td>13</td>
<td>Tracing capability / Sales representative / Sailing frequency / Transit time / Directness of sailing / On-time pick-up and delivery / Cost of service / Cooperation between personnel / Carrier flexibility / Reputation for reliability / Loss and damage experience / Informational nature of advertising / Carrier appropriateness</td>
</tr>
<tr>
<td>1989, 1991, 1992</td>
<td>Murphy et al.</td>
<td>9</td>
<td>Large and, or odd sized freight / Large volume shipment / Special handling / Equipment availability / Shipment information / Loss and damage / Pick-up and delivery / Handling charge / Claim handling</td>
</tr>
<tr>
<td>1993</td>
<td>Frankel</td>
<td>9</td>
<td>Availability of capacity / Cargo flow control and tracking / Service reliability / Service time and delivery time / Cargo safety, security and maintenance / Timeliness and accuracy / Cost control, billing and management / Service status control and projection / Intermodal management</td>
</tr>
<tr>
<td>1998</td>
<td>Lopez et al.</td>
<td>3</td>
<td>Timeliness / Security / Efficiency</td>
</tr>
<tr>
<td>1999</td>
<td>Durvasula et al</td>
<td>5</td>
<td>Tangibles / Reliability / Responsiveness / Assurance / Empathy</td>
</tr>
<tr>
<td>2002</td>
<td>Tongzon</td>
<td>7</td>
<td>Adequate infrastructures / Location / Frequency of ship visits / Competitive port charges / Quick response to port users’ needs / Port efficiency / Port’s reputation for cargo damage</td>
</tr>
</tbody>
</table>
2.5. Data Collection and Gap Analysis

2.5.1. Methodology

Data collection has been carried out by implementing the “stand in the circle” (Go to Gemba) concept to collect real data to identify the current value stream map and identify waste that should be eliminated in order to achieve a significant level of customer satisfaction. The choice of respondents includes shipping lines, shipping agencies, terminal operators and cargo clearing agencies from the port of Umm Qasr. The selection comprises those having sufficient experience with port services. Data collected from these respondents was analyzed using SPSS software. The aim was not to compare port services with other ports but rather to measure the service quality of this specific port and customer satisfaction from the customers’ perspective. Service quality should be defined in the context of the port sector to get a clearer picture of the quality elements that should be included in the questionnaire. In the current paper, the ROPMEE model has been developed by the researcher based on the ROPMIS model, which was introduced by Thai (2008) to measure service quality in the cargo delivery process in the Port of Umm Qasr as it covers all the functional and non-functional areas in the cargo delivery process.
compared to other quality dimensions. Thai (2008) has argued that the factors of this model can be readily revised for subsectors in the maritime industry such as ports, as this model has been previously used by Dao et al. (2013) in an exploratory study. The six service quality dimensions of the ROPMEE model are illustrated in Table 2.

Table 2: ROPMEE Model

<table>
<thead>
<tr>
<th>Quality Dimension</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources</td>
<td>Relates to physical resources, financial resources, condition of facilities, equipment, location, infrastructures</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Involves the product or core services that are being received by the customers</td>
</tr>
<tr>
<td>Process</td>
<td>Relates to the interactions between employees and customers</td>
</tr>
<tr>
<td>Management</td>
<td>Involves professionalism which ensures resources are transformed into customer requirements efficiently and professionally</td>
</tr>
<tr>
<td>Environmental Responsibility</td>
<td>Involves the perception and operations of an organization to behave in an environmental friendly responsible manner</td>
</tr>
<tr>
<td>Energy Management</td>
<td>Related to the overall perception of energy management, technology and type of energy used</td>
</tr>
</tbody>
</table>

Source: Thai, 2008 and Authors, 2015

The SERVQUAL method was used in this study to measure customer satisfaction towards the quality of services in the process of port operations at the port of Umm Qasr. Therefore, two sets of questionnaires were used to assess the perception and expectation of customers with 30 closed fixed alternative questions, which were developed from 30 quality elements as demonstrated in Table 3. The quality elements were segregated according to the six quality dimensions of the ROPMEE model. A 7 point Likert scale was used in this study, anchored by 1 = strongly disagree with the statement, through to 7 = strongly agree with the statement, with 4 equating to the midpoint as the responders were asked to rate the level of agreement with the statements provided in the questionnaire. The statements were made positively, so 7 indicates highest customer satisfaction or highest expectation with the relevant quality element.
### Table 3: Questionnaire Design

<table>
<thead>
<tr>
<th>Quality Dimension</th>
<th>Codes</th>
<th>Quality element</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Resources</strong></td>
<td>SQ1</td>
<td>1- Modern cargo handling equipment</td>
</tr>
<tr>
<td></td>
<td>SQ2</td>
<td>2- Adequate cargo storage facilities</td>
</tr>
<tr>
<td></td>
<td>SQ3</td>
<td>3- Availability of skilled manpower</td>
</tr>
<tr>
<td></td>
<td>SQ4</td>
<td>4- Availability of cargo handling equipment</td>
</tr>
<tr>
<td></td>
<td>SQ5</td>
<td>5- Adequate port operation system POS</td>
</tr>
<tr>
<td></td>
<td>SQ6</td>
<td>6- Adequate port layout</td>
</tr>
<tr>
<td><strong>Process</strong></td>
<td>SQ7</td>
<td>7- Proper ship arrival notification process</td>
</tr>
<tr>
<td></td>
<td>SQ8</td>
<td>8- Processing documents and cargo unloading with minimum delays</td>
</tr>
<tr>
<td></td>
<td>SQ9</td>
<td>9- Sufficient vessel planning process</td>
</tr>
<tr>
<td></td>
<td>SQ10</td>
<td>10- Stabilized work schedule</td>
</tr>
<tr>
<td></td>
<td>SQ11</td>
<td>11- Proper visual feedback system for port operations</td>
</tr>
<tr>
<td></td>
<td>SQ12</td>
<td>12- Reliable Practical problem solving process</td>
</tr>
<tr>
<td><strong>Outcome</strong></td>
<td>SQ13</td>
<td>13- Shorter changeover time between shifts</td>
</tr>
<tr>
<td></td>
<td>SQ14</td>
<td>14- Capabilities of providing services without delays</td>
</tr>
<tr>
<td></td>
<td>SQ15</td>
<td>15- Safer Cargo Operation</td>
</tr>
<tr>
<td></td>
<td>SQ16</td>
<td>16- Assurance of shipment and operations security</td>
</tr>
<tr>
<td></td>
<td>SQ17</td>
<td>17- Shorter Vessel Turnaround Time VTT</td>
</tr>
<tr>
<td><strong>Management</strong></td>
<td>SQ18</td>
<td>18- Involvement of ground workers in improvement process</td>
</tr>
<tr>
<td></td>
<td>SQ19</td>
<td>19- Good quality assurance measures in place</td>
</tr>
<tr>
<td></td>
<td>SQ20</td>
<td>20- Management capability of performing duties skillfully</td>
</tr>
<tr>
<td></td>
<td>SQ21</td>
<td>21- Level of bureaucracy</td>
</tr>
<tr>
<td></td>
<td>SQ22</td>
<td>22- Efficiency in operations and management</td>
</tr>
<tr>
<td></td>
<td>SQ23</td>
<td>23- Proper responsiveness to customer complaints</td>
</tr>
<tr>
<td><strong>Environmental responsibility</strong></td>
<td>SQ24</td>
<td>24- Concerns for environmental friendly operations</td>
</tr>
<tr>
<td></td>
<td>SQ25</td>
<td>25- Existence of an environmental management system</td>
</tr>
<tr>
<td></td>
<td>SQ26</td>
<td>26- Adequate port reception facilities</td>
</tr>
<tr>
<td></td>
<td>SQ27</td>
<td>27- Pollution potential assessment and assessment of potential consequences</td>
</tr>
<tr>
<td><strong>Energy Management</strong></td>
<td>SQ28</td>
<td>28- Efficient energy management process</td>
</tr>
<tr>
<td></td>
<td>SQ29</td>
<td>29- Use of clean and renewable energy</td>
</tr>
<tr>
<td></td>
<td>SQ30</td>
<td>30- Use of technology to reduce fuel consumption</td>
</tr>
</tbody>
</table>

The survey questionnaire was originally written in English and later translated into the Arabic language spoken by the respondents for the purpose of administrating the survey with minimal difficulty. The survey was conducted on a one-to-one basis between the
researcher representative and the interviewee. Respondents were asked to rate the perceived experience of the quality of services in section one and their expectation in section two, using the same 30 quality elements. The population comprises 60 targeted shipping lines (19), agencies (26), operators (4) and certified cargo clearing agencies (11). However, only 39 responses were received mostly from shipping lines (14) and agencies (18), representing 65% of the targeted population.

2.5.2. SERVQUAL test

As shown in Table 4, the overall alpha value of the perception data is higher than 0.8. Alpha values (if the element is deleted) for the quality elements ranged from 0.811 to 0.830, which implies all elements are reliable for this research instrument. Only SQ14 and SQ29 show a slight improvement in the internal consistency if those items are deleted from the survey instrument, but neither of those improvements is significant enough to be taken into the consideration. Therefore, it can be concluded that this research instrument has good internal consistency.

Table 4: Reliability test for perception of customers

<table>
<thead>
<tr>
<th></th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item Total Correlation</th>
<th>Squared Multiple Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQ1</td>
<td>85.7436</td>
<td>238.248</td>
<td>.316</td>
<td>.880</td>
<td>.820</td>
</tr>
<tr>
<td>SQ2</td>
<td>85.7179</td>
<td>232.366</td>
<td>.437</td>
<td>.827</td>
<td>.816</td>
</tr>
<tr>
<td>SQ3</td>
<td>85.8974</td>
<td>229.042</td>
<td>.536</td>
<td>.826</td>
<td>.812</td>
</tr>
<tr>
<td>SQ4</td>
<td>86.0769</td>
<td>231.652</td>
<td>.391</td>
<td>.770</td>
<td>.817</td>
</tr>
<tr>
<td>SQ5</td>
<td>84.9744</td>
<td>229.078</td>
<td>.385</td>
<td>.757</td>
<td>.818</td>
</tr>
<tr>
<td>SQ6</td>
<td>85.5641</td>
<td>233.831</td>
<td>.308</td>
<td>.863</td>
<td>.821</td>
</tr>
<tr>
<td>SQ7</td>
<td>85.5641</td>
<td>232.937</td>
<td>.366</td>
<td>.910</td>
<td>.818</td>
</tr>
<tr>
<td>SQ8</td>
<td>85.8718</td>
<td>230.273</td>
<td>.454</td>
<td>.876</td>
<td>.815</td>
</tr>
<tr>
<td>SQ9</td>
<td>85.1538</td>
<td>233.870</td>
<td>.288</td>
<td>.795</td>
<td>.822</td>
</tr>
<tr>
<td>SQ10</td>
<td>85.8718</td>
<td>234.325</td>
<td>.397</td>
<td>.881</td>
<td>.817</td>
</tr>
<tr>
<td>SQ11</td>
<td>85.5385</td>
<td>238.992</td>
<td>.234</td>
<td>.686</td>
<td>.824</td>
</tr>
<tr>
<td>SQ12</td>
<td>85.3846</td>
<td>225.348</td>
<td>.538</td>
<td>.774</td>
<td>.811</td>
</tr>
<tr>
<td>SQ13</td>
<td>85.5897</td>
<td>230.406</td>
<td>.442</td>
<td>.897</td>
<td>.815</td>
</tr>
<tr>
<td>SQ14</td>
<td>85.5385</td>
<td>249.623</td>
<td>.021</td>
<td>.580</td>
<td>.829</td>
</tr>
<tr>
<td>SQ15</td>
<td>85.5897</td>
<td>236.354</td>
<td>.388</td>
<td>.874</td>
<td>.818</td>
</tr>
<tr>
<td>SQ16</td>
<td>85.2051</td>
<td>237.904</td>
<td>.279</td>
<td>.888</td>
<td>.822</td>
</tr>
<tr>
<td>Item (SQ)</td>
<td>Scale Mean if Item Deleted</td>
<td>Scale Variance if Item Deleted</td>
<td>Corrected Item Total Correlation</td>
<td>Squared Multiple Correlation</td>
<td>Cronbach’s Alpha if Item Deleted</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------------</td>
<td>--------------------------------</td>
<td>----------------------------------</td>
<td>-------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>SQ1</td>
<td>147.3000</td>
<td>86.838</td>
<td>.317</td>
<td>.342</td>
<td>.708</td>
</tr>
<tr>
<td>SQ2</td>
<td>147.2333</td>
<td>87.909</td>
<td>.215</td>
<td>.456</td>
<td>.715</td>
</tr>
<tr>
<td>SQ3</td>
<td>147.4667</td>
<td>84.464</td>
<td>.309</td>
<td>.232</td>
<td>.708</td>
</tr>
<tr>
<td>SQ4</td>
<td>146.3667</td>
<td>87.895</td>
<td>.319</td>
<td>.543</td>
<td>.709</td>
</tr>
<tr>
<td>SQ5</td>
<td>146.1667</td>
<td>88.489</td>
<td>.236</td>
<td>.512</td>
<td>.714</td>
</tr>
<tr>
<td>SQ6</td>
<td>146.9333</td>
<td>83.926</td>
<td>.389</td>
<td>.374</td>
<td>.702</td>
</tr>
<tr>
<td>SQ7</td>
<td>146.8000</td>
<td>86.097</td>
<td>.299</td>
<td>.454</td>
<td>.709</td>
</tr>
<tr>
<td>SQ8</td>
<td>147.0000</td>
<td>87.034</td>
<td>.308</td>
<td>.371</td>
<td>.709</td>
</tr>
<tr>
<td>SQ9</td>
<td>146.6333</td>
<td>85.551</td>
<td>.339</td>
<td>.298</td>
<td>.706</td>
</tr>
<tr>
<td>SQ10</td>
<td>147.0000</td>
<td>88.345</td>
<td>.246</td>
<td>.370</td>
<td>.713</td>
</tr>
<tr>
<td>SQ11</td>
<td>146.6667</td>
<td>89.609</td>
<td>.206</td>
<td>.334</td>
<td>.715</td>
</tr>
<tr>
<td>SQ12</td>
<td>146.7333</td>
<td>83.995</td>
<td>.400</td>
<td>.444</td>
<td>.701</td>
</tr>
<tr>
<td>SQ13</td>
<td>146.8667</td>
<td>85.223</td>
<td>.401</td>
<td>.517</td>
<td>.703</td>
</tr>
<tr>
<td>SQ14</td>
<td>146.8000</td>
<td>92.924</td>
<td>-.109</td>
<td>.321</td>
<td>.728</td>
</tr>
</tbody>
</table>

According to Table 5, the overall value for Cronbach’s alpha for section 2 of the questionnaire is 0.720, thus providing evidence that this questionnaire has internal consistency. Mean scores are based on a seven point Likert scale (1=strongly disagree, 7=strongly agree)

Table 5: Reliability test for Expectation of customers
As shown in Table 6, the sample is almost the same as the mean and standard deviation values that were significantly calculated with relevance to each quality element. Therefore, considering the sample as a single data set has carried out for all the calculations in this study.

Table 6: Sample Group Statistics

<table>
<thead>
<tr>
<th></th>
<th>Perception</th>
<th></th>
<th>Expectation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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According to the SERVQUAL calculation shown in Table 7, it appears that customers are highly dissatisfied with the services provided by the Port in relation to the process quality dimension.

SQ8 (Processing documents and cargo unloading with minimum delays) has a gap of -4.1282 as there is a huge problem related to delays in processing cargo unloading and related documents in the Port of Umm Qasr. Procedures for most of the port activities are insufficient to cater for increasing volume. Thus, some steps in the process take longer than expected, which is dissatisfying to the customer. According to the data available in the Table 7, customers are highly dissatisfied with the port reception facilities.

SQ26 (Adequate port reception facilities) for the Port of Umm Qasr, has a negative gap of -3.9487 because there is no sophisticated waste treatment system currently installed to handle vessel waste.
SQ1 (Modern cargo handling equipment) also has a negative gap (-2.5641) as most of the equipment used for handling general cargo at the Port of Umm Qasr is old, thus most of the shore cranes and forklifts experience frequent breakdowns, which delay the whole cargo handling process. However, the gap of SQ1 is comparatively less (by +0.3761) than the average gap of the resources dimension and has the smallest negative gap. Therefore, it can be concluded that although equipment does not need to be the latest, it should be in good condition to provide productive and efficient service.

SQ2 (Adequate cargo storage facilities) has the highest negative service gap (-3.3077) among the quality elements of the Resources dimension, as there is a problem related to the condition of the warehouse facilities in the Port of Umm Qasr. The capacities of most of the warehouses are insufficient to cater for existing demand, especially for dangerous goods. Thus, some cargos are stored outside the warehouses, exposing them to rain, dust and heat.

SQ3 (Availability of skilled manpower) received a negative service gap (-3.2564) due to the lack of planned training programs and policy of position selection.

SQ4 (Availability of cargo handling equipment) received a negative service gap (-2.5897); previously, multiple break-bulk vessel operations were severely restricted by the limited availability of operational forklifts, shore cranes and yard trucks. This is especially true for the smaller 3 to 5-ton forklifts and 8-15 ton shore cranes. As an example, if three vessels were working simultaneously with multiple gangs, up to eighteen 3 to 5-ton forklifts and twelve shore cranes would be required. When considering the total forklifts required for vessel, yard, and maintenance operations, the number of smaller lifts quickly multiplies. Currently, the port has purchased some cargo handling equipment and the involvement of the private sector has increased the availability level, but it is still insufficient, especially during peak periods.

SQ5 (Adequate port operation system POS) received a negative service gap (-3.1026) because there is no comprehensive and fully integrated POS that provides a secure, real-time view of information and activity across the port. Ports and Shipping today cannot operate effectively without comprehensive Information Management Systems. These include Automatic Identification Systems (AIS), Vessel Traffic Service (VTS) and Port Operating Systems (POS). Such systems, when combined with a Port Community System
acting as the hub, are able to offer a wide range of advantages to the transport sector in Iraq by improving the efficiency and productivity of port operations. The benefits of these improvements pass not only to port operators but also to port customers including shipping lines, freight forwarders, and shipping agents.

SQ6 (Adequate port layout) received a negative service gap (-2.8205) because the cargo handling operations hinder each other, as there is no clear separation between different types of cargo and operations. Buildings and administrative activities are located in different areas, requiring more movement for customers so they should be as far back in the terminal as possible and integrated into the central office. The truck staging area is located between primary operations areas, but would be better located as far back in the terminal as possible. Warehouses are not located at a safe distance from the waterside operations to cater for efficient operation of the vessels. Container terminal operation is not separated from conventional cargo operations and Ro-Ro operation.

SQ7 (Proper ship arrival notification process) received a negative service gap (-2.9231) due to the use of traditional methods of communication with vessels calling the port control using VHF and SSB. A new AIS system was installed recently to monitor the arrival of vessels at the entrance to the port on a first come first served basis for similar cargo.

SQ9 (Sufficient vessel planning process) received a negative service gap (-3.6923) because most of the operations are paper based and many variations can occur during cargo unloading. The planning of vessel operations appears to be a difficult task.

SQ10 (Stabilized work schedule) received a negative service gap (-3.3590) as a result of involving different authorities in planning the operations and decision-making practices.

SQ11 (Proper visual feedback system for port operations) received a negative service gap (-3.3846) because all data collection is carried out manually and there is no POS in place to provide such feedback.

SQ12 (Reliable Practical problem solving process) received a negative service gap (-3.4103), as the level of data accuracy is low since it comes from several sources using different methods of presenting their data. On the other hand, the management of the port is not fully authorized to practically solve problems due to the management structure and
level of authorization. The Process quality dimension received a highest negative service gap (-3.4829) among quality dimensions.

SQ13 (Shorter changeover time between shifts) received a negative service gap (-3.8718) which is the third highest service gap. Changeover time is longer than the customer expects especially between the night shift and the daytime shifts, which sometimes takes 3-4 hours.

SQ14 (Capabilities of providing services without delays) received a negative service gap (-3.7436) due to several breakdowns during the service providing process and also because of truck congestion within port operations. These delays in providing services limit the port’s capacity because ships are utilizing berths longer than required.

SQ15 (Safer Cargo Operation) received a negative service gap (-3.3333) as many ships arrive at the port carrying unsecured cargo with poor stowage plans or unsecured small loose items. Furthermore, the handling equipment and attachments are not certified according to global standards, leading to many accidents reported by the port authority.

SQ16 (Assurance of shipment and operations security) received a negative service gap (-3.1026) as the port’s compliance with the ISPS code is under processing by a third party after an IMO delegation visited the port in 2013 and reported that the port needed to take serious measures in this regard.

SQ17 (Shorter Vessel Turnaround Time VTT) received a negative service gap (-3.1795) as a result of the lack of yard transfer equipment, equipment breakdowns, quay crane operating speed and equipment operator availability, which are the most critical factors towards VTT in port operations. The outcome quality dimension received a negative average service gap (-3.4462) as the second highest quality dimension.

SQ18 (Involvement of ground workers in improvement process) received a negative service gap (-3.0769) as there is a gap between the management and the ground workers preventing them from sharing their ideas on developing port operations and service level.

SQ19 (Good quality assurance measures in place) received a negative service gap (-3.0513) mainly because the quality standards, such as the ISO standard, are not thoroughly followed and implemented.
### Table 7: SERVQUAL calculations

<table>
<thead>
<tr>
<th>SQ</th>
<th>Perception (P)</th>
<th>Expectation (E)</th>
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</thead>
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<td>Frequency of responses</td>
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<td>5.8718</td>
</tr>
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</table>

**Table 7 Format Source** - Ferreira and Oliviera (2009)
SQ20 (Management capability of performing duties skillfully) received a negative service gap (-3.0256) because the job description of the management role is not clearly defined, resulting in selection of the management position without considerable skill requirements. On the other hand, the tools for measuring management performance need to be specified in order to evaluate management’s performance internally.

Figure 5. Quality Dimension Levels (Perception- Expectation)

SQ21 (Level of bureaucracy) received a negative service gap (-3.4872) as most of the procedures are carried out by paper work, requiring different levels of approval and tens of signatures with stamps. SQ22 (Efficient in operations and management) received a negative service gap (-2.6410), as operational efficiency is what takes place when the
right combination of process, people, and technology come together, and these have been shown previously to have negative gaps.

SQ23 (Proper responsiveness for customer complaints) received a negative service gap (-3.2564) as the management needs to analyze complaints thoroughly by reviewing a number of factors such as who lodged the complaint and how often this client complains - then take proper actions to ensure that the problem is solved.

SQ24 (Concerns for environmental friendly operations) received a negative service gap (-3.1026) showing that most people in the port are not aware of or concerned about damage to the environment caused by port operations.

SQ25 (Existence of an environmental management system) received a negative service gap (-3.4359), as there is no such system in place to reduce damage to the environment resulting from port operations and the impact of maritime accidents and shipping traffic.

SQ27 (Pollution potential assessment and assessment of potential consequences) received a negative service gap (-3.2308) as the port needs to develop a reliable testing process and procedure for long term and short term environmental risk assessment. Assessing the risk of pollution enables the port authority to maximize its preparedness in order to minimize damage and loss.

SQ28 (Efficient energy management process) received a negative service gap (-3.4103) as the port needs to have an energy management plan to maximize energy savings and resolve energy management problems. Customers are concerned with energy management efficiency as it has a direct impact on service cost.

SQ29 (Use of clean and renewable energy) received a negative service gap (-3.8718) as the second highest service gap because the port mainly uses fuel to generate energy. Alternative energy sources and renewable energy can be introduced in the port such as wind power and solar power.

SQ30 (Using technology to reduce fuel consumption) received a negative service gap (-3.0256) due to the weak or nonexistent use of technology to consume fuel efficiently in order to operate cargo-handling equipment. Adoption of new technologies and innovations by the port authority will have a positive impact on reducing fuel consumption as well as reducing emissions.
In order to demonstrate the level of importance of the dimensions, the targeted group was asked to give a score to each dimension by allocating a total of 100 points among six dimensions according to how important each dimension is to them.

Table 8: SERVQUAL weighted score calculation

<table>
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<th>SERVQUAL Dimension</th>
<th>SERVQUAL score*Importance weight</th>
<th>Weighted Score</th>
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<tr>
<td>Average Resources</td>
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<tr>
<td>Average Process</td>
<td>-3.4829*19.64</td>
<td>-68.404</td>
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<tr>
<td>Average Outcome</td>
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<td>-66.615</td>
</tr>
<tr>
<td>Average Management</td>
<td>-3.0897*19.35</td>
<td>-59.786</td>
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<tr>
<td>Average Environmental</td>
<td>Responsibility</td>
<td>-3.4295*11.43</td>
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<tr>
<td>Average Energy Management</td>
<td>-3.4359*9.52</td>
<td>-32.709</td>
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<td>Total weighted SERVQUAL score</td>
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<td>-327.663</td>
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<tr>
<td>Average weighted SERVQUAL score</td>
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<td>-54.611</td>
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</table>

The average Process quality dimension demonstrates the highest impact on the quality of services where the weighted SERVQUAL score is -68.404, followed by the average Outcome quality dimension of -66.615, while the average SERVQUAL score is -54.611 as shown in Table 8. This demonstrates the degree of impact that the process dimension makes on the level of service quality delivered at the Port of Umm Qasr. Therefore, special attention should be given to the criteria in the Process quality dimension in order to improve the quality of services.

The Lean Approach provides a method and tools for process development, taking into consideration customer value as first priority. Therefore, further steps to this research were taken by mapping the value stream of the port process and identifying process wastes to be eliminated.

The resources quality dimension shows the third largest impact (-60.950), which is higher than the average weighted SERVQUAL score because port customers have given it the
highest score among other dimensions. However, the port facilities and infrastructure could be utilized efficiently if the operations were significantly processed. The average management quality dimension also shows a significant impact on the quality of service, as the weighted score is -59.786, which is also higher than the average.

The respondents scored the Environmental responsibility quality dimension as being less important than other dimensions of service quality, similar to the energy management quality dimension. Therefore, results show that environmental responsibility and energy management, which received -39.199 and -32.709 respectively, are lesser than the average weighted SERVQUAL score. The port authority needs to employ proper methods to improve operational performance of current practices as all quality dimensions received negative service gaps.

Table 9: Validity Test

<table>
<thead>
<tr>
<th>Source: Author, 2017</th>
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In order to validate the findings of SERVQUAL test, using SPSS analysis as shown in table 9 above has carried out a validity test. The values of the correlation between the quality dimensions are greater than 0.5 meaning that the statistical test in this research was valid.
Table 10 explains the meaning of each quality element according to Lean deadly wastes and their impacts on the service cost, environment, service speed and energy consumption.

Table 10. SERVQUAL test and waste identification

<table>
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<th>No</th>
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<th>Impact on</th>
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2.6. Umm Qasr Port Processes Overview

Umm Qasr Port is the largest Iraqi foreign trade cargo port and the only port facing the Arab Bay in the Arabian Gulf adjacent to the Kuwait border. The Umm Qasr Port is the most multifunctional primary port in Iraq. The port is located close to the border with Kuwait near the entrance of the Arabian Gulf on the west bank of the Khor Al Zubayer River, approximately 90 km upstream from the northwest edge of the Arabian Gulf and 75 kilometers from the southern entrance to the western city of Basra.

The growing movement of foreign trade and congestion in Maqal port during the mid-1900s called for the need to consider the establishment of a new port. Due to the proximity of the Arabian Gulf, absence of a passing channel for ship navigation and the depth of the river preventing Maqal port from receiving ships with larger draughts, construction on Umm Qasr Port began in 1958 and the first phase was completed in 1965. Since the completion of the urgent dredging project by UNDP in 2003 and removal of sunken ships in the port channel, 50,000 DWT size vessels have been able to enter Umm Qasr Port at the high tide level and the function of the port was recovered to a limited extent. However, the required water depth was not achieved for whole area of the channel and port basin, and consequently utilization of cargo handling operations is only 50% of the port sector’s designed capacity (JICA, 2012).

Umm Qasr Port is the main port for general cargo, project cargo, RoRo, and containers in Iraq. The port is connected to the hinterland by a developed road and rail inland network. Umm Qasr Port handles multiple types of cargo, such as cars, pipes and steel products, passengers, general cargo, cement, sugar, rice, wheat, and containers. The current operation of the Port is characterized by operations and administrative procedures, where most data and information exchange is carried out on paper in offices at multiple locations inside the port operations area. This results in operational delays and in private individuals and vehicles entering the port operations area. To improve operation processes, it is important for a Port Manager to understand whether the port is performing efficiently.

For Umm Qasr Port, the SERVQUAL test illustrated that there is more to improving port processes than just measuring it. If the port authority implements the Lean approach, they
can use a combination of process performance measurement tools and process improvement methods. Lean offers port operations a holistic approach that benefits other transferable port activities including marine services, ship loading/unloading, storage and delivery operations, logistics, environment protection and energy management. The fragmented approaches may fail to take into account all related issues encompassing the ports, indicating that more studies are needed to overcome the shortcomings. On the other hand, previous studies on port performance generally take into account the Port Performance Indicators PPIs mostly from the port planners’ perspectives with a focus on seaside operations. Further, the PPIs measure the operation performance by determining the ship operation, yard operation, storage operation, and gate operation separately. In this regard, we suggest a new measure of using Lean approach to examine entire port operations taking into consideration customer demand as the core of the port business.

Evaluating the performance of the selected port based on data collection using the *go-gemba* technique was deemed to be supported by the need for more clarity and bias avoidance. Therefore, an empirical study was conducted to examine the service quality of the cargo handling process at the Port of Umm Qasr in order to evaluate the performance. Measuring the quality of a service can be a very difficult research exercise and it is slightly different than measuring product quality because there are detailed specifications such as weight, color, length, width, and depth, while intangible or qualitative specifications may be involved in assessing a service. Moreover, customer expectation with regard to service, which can differ considerably, may show different results as it relies on a number of factors such as previous experience, personal requirements and what others may have told them. The service quality level for the port of Umm Qasr was examined using a SERVQUAL model called ROPMEE as a modified model of ROPMIS. Six quality dimensions were used and thirty quality elements were designed to determine the perceptions and expectations of the port’s customers. The findings confirm that the process quality dimension is the most influential factor in service quality at the Port of Umm Qasr. The reason for the current poor performance practices adopted by the port is the use of traditional ways of information flow and decision making, which require more time and steps within the whole process. Lack of smooth process flow possibly causes bottlenecks within port operations that create serious problems not only for customers but
also for the port itself. The findings also show an imbalance between the port resources and their outcomes, which require greater attention in order to eliminate the impact of any negative step in the process.

According to PwC and Panteia (2013) and by studying available data, the author suggests that many ports including the Port of Umm Qasr is facing difficulties in:

1. Availability: range of services provided within the port area;
2. Speed: time taken to service ships and cargo;
3. Reliability: consistency of port performance; and
4. Flexibility: ability to provide alternative solutions when things go wrong
5. Bureaucracy
6. Information Flow
7. Authority Conflicts
8. Compliance with Environment protection Standards and Regulations
9. Energy Management

However, examining all the above-mentioned difficulties by implementing a systematic approach exceeds the scope of this research. Therefore, the research focus is concentrated on determining the identification of port process waste and the benefits of waste elimination for the port and its clients.

The determination of substantial responsiveness of port customers was split in two parts; i.e. (i) an assessment of responsiveness to six quality dimensions, and (ii) assessment of the responsiveness to thirty quality elements. The results revealed that the process quality dimension has received the highest score of negative impact. The identified problem through using SERVQUAL test requires a solution for process improvement compatible with, new operations and administrative practices would be opportune. An improved process combined with modified organizational setups is prerequisites for the implementation of Lean in order to handle this problem. As the Lean Approach provides a method and tools for identifying process waste and result in process improvement, taking into consideration customer value as first priority. Therefore, Lean approach was selected to examine the existing port processes and further steps to this research were taken by mapping the value stream of the port process and identifying process wastes to be eliminated. The next chapter is planned to define the meaning of Lean and how this
philosophy has been used in the manufacturing sector as well as the service sector. The selection of the proper Lean tools is based on the results of SERVQUAL test that highlighted the difficulties in the port processes.
Chapter Three: Lean Approach and Port Processes

3.1. Understanding Lean

Lean is an improvement approach whose main focus is on waste elimination and non-value added activities. It was derived by the Toyota Company and pioneered by Taiichi Ohno, the Toyota Executive, and Shigeo Shingo who identified the seven types of waste (muda) based on the principles of Henry Ford (Womack, & Jones, 2003). Taiichi Ohno defined waste as “anything other than the minimum amount of equipment, materials, parts and working time which is absolutely essential to add to the product or service”. Toyota Corporate that hinders the ability to add value into product or service was the first company who identified the seven deadly waste categories.

Lean concept, which is often referred to as Lean Manufacturing, is a philosophy of production or service process improvement through waste elimination. In other words, Lean concept is not a destination, rather it is a journey of continuous improvement, making more products/services and using fewer resources to satisfy company clients in a consistent manner. This can be achieved through producing what they require when they request it by pulling product or service from the value stream, engaging the limited number of resources through involving all employees in a continuous process improvement, and getting it right the first time. Ohno, (1988) stated that in order to understand Lean concept in the best way, it is better to start with its origin in the Toyota Production System.

The Toyota Company began the implementation of Lean by adopting the principles suggested by Henry Ford with the dynamic car assembly line. The waste elimination and processes standardization has breached the significance of providing a continuous flow for materials. Therefore, millions of black Model-Ts were turned out by Ford Company and developed to wasteful batch manufacturing systems of building up large storage for inventory of work-in-process throughout production value chain by pushing a product onto the production next stage. On the other hand, Toyota Car Manufacturing were lacking space and money and they did not have this luxury and they had to evolve a method that could respond flexibly to clients demand and be efficient simultaneously. Hence, The Toyota Production System (TPS) was introduced to enable the company to become more competitive with Ford in world markets, while overcoming the specific
circumstances they faced in Japan. Toyota spent several years experiencing a trial and error practice on the shop floor when they finally discovered that they could simultaneously successfully reached just-in-time, low cost and high quality product delivery by “eliminating waste which led to shortening the production flow”. With this concept that is the heart of the Toyota Production System, this system as a production paradigm is distinguished from the older system of mass production. The main focus is on eliminating waste and shortening the production flow whenever they gets in the process of a smooth flow. Continuous one-by-one piece flow is the theoretical ideal situation, while it is rarely realized. Therefore, practitioners of the Toyota Production System believe that system performance will be improved if the production system is progressing toward continuous flow by waste elimination.

In order to clearly understand what this new paradigm of production or “Lean production” is, this research attempts to briefly review the history of American mass production and consider how Toyota’s planners deviated their path from that trajectory.

3.2. Sectorial Usage of Lean

3.2.1. Manufacturing and production

Lean manufacturing or production is a major manufacturing paradigm being exercised in numerous sectors of the United States of America economy, where cutting unnecessary production costs, improving the quality of products, being in the leading position in the market and immediate response to customer demands are critical to success and competitiveness (U.S. Environmental Protection Agency, 2003). Lean methods and principles emphasize the creation of a culture for continual improvement that involves ground workers in minimizing the intensity of materials, capital and time necessary for meeting a customer’s needs. While the fundamental focus of Lean approach is on the systematic elimination of waste and non-value added activity from the process, the implementation of Lean methods and principles also leads to improved environmental performance. Worldwide, numerous organizations of different size across multiple industry sectors, primarily in the production and service sectors, are adopting such Lean manufacturing systems, and many experts have reported that the rate of Lean implementation is accelerating. Basically, organizations choose the implementation of
Lean manufacturing for three reasons: to improve the quality of their product, reduce manufacturing resource requirements and costs; and to increase customer responsiveness, all of which combine to increase organizational competitiveness and profits. In order to achieve these process improvements and associated waste elimination, Lean primarily engages a significant paradigm move from traditional “batch and queue” mass production to “one-piece flow” pull production. While “batch and queue” require large stacks of products in advance depending on predicted or potential customer demands, a “one-piece flow” principle rearranges manufacturing activities differently by processing production steps to be conducted instantly adjacent to each other in a continuous flow (U.S. Environmental Protection Agency, 2003).

As Lean has prospered since its initiation in the car industry, it has been extended to apply to various organizations and sectors, and has achieved a reputation for reducing/eliminating waste while adding value to products or services. In the 1990s, several large, medium, and small suppliers of automotive parts started the transition to implementation of the Lean production concept. As auto assemblers implemented just-in-time systems, their anticipation for improved quality, cost and responsiveness from component suppliers also grew. A number of production companies informed their suppliers that they would stop paying the high costs associated with large inventories. The number of automotive suppliers implementing Lean production systems has increased, which has resulted in meeting these improvements of low cost, high quality, responsiveness expectations and increasing profitability. In some instances, large auto manufacturers are encouraging and supporting their suppliers to implement Lean systems. For instance, in 1992, the Toyota Supplier Support Center was initiated by Toyota car production in Lexington, Kentucky to offer free support to companies in the U.S. interested in understanding and learning about how to implement Lean manufacturing. Delphi Corporation, Johnson Controls, Eaton Corporation and Donnelly Corporation have implemented Lean as examples of large integrated automotive suppliers. Numerous other medium-sized manufacturing companies in diverse sectors such as the Wiremold Company, Freudenberg-NOK, the Danaher Corporation and Garden State Tanning were early adopters of Lean systems and have posted significant improvements in quality, productivity, and cost competitiveness.
In the early 1990s, the aerospace industry stepped up initiatives to adopt the Lean production concept. In order to ensure successful Lean implementation in the aerospace sector, the U.S. Air Force together with the Massachusetts Institute of Technology, labor unions and 25 aerospace companies initiated the Lean Aerospace Initiative in 1993. Large aerospace companies such as Boeing, Raytheon and Lockheed Martin, across many divisions of their organizations, are implementing Lean production systems. Likewise, implementation of Lean by aerospace components and parts suppliers, such as Goodrich Corporation, has grown rapidly. In recent years, the U.S. Air Force has made aggressive moves toward implementing Lean methods throughout its production operations, beginning with Air Logistics Centers passing through contractor manufacturing and ending with maintenance operations.

The shipbuilding industry is obviously different to the automotive industry as it is not possible to see the assembly line producing a vessel every minute with relatively standard configurations. Normally, vessels are built to order by customers, a few or one at a time over months or weeks and are largely highly customized. The question here is “is the Lean manufacturing model worth considering?” Clearly the answer should be yes. However, for it to work, there are also a number of conditions that must be in place such as low variability and sufficient throughput.

First, the fundamental principles of offering clients what they request with shortened lead times through waste elimination are applicable to any process, low volume or high volume, standardized or customized. While the methodology of how Toyota Company adopts the Lean approach in their specific circumstances might not fit all, the principles and philosophy have been precisely tuned to a greater art form by the Toyota Company. Second, the Toyota Production System philosophy can be seen at work in building ships when world-class shipbuilding models are examined. For instance, well known Japanese shipyards are considered among the most efficient shipyards and have used relatively modular, standardized designs to build what some call ship factories—factories where there is a constant intermediate and basic product flow, built into moving lines of production, and construction material is sequenced carefully and transported through the building yard in a Just-In-Time system (a cautiously orchestrated flowing pattern).
Construction raw material, such as steel plates, is brought to the yard on a JIT basis and not months in advance to sit as inventory and wait to be used. Quality of products is built in at the source and process, rather than separately inspected in where all processes are highly timed and standardized. Therefore, product quality is not the responsibility of just a select few inspectors but it is each ground worker’s responsibility.

In the United States, shipyards have not competed on the world market, rather serving a commercial market and highly protected U.S. defense. In order for U.S. shipyards to reestablish themselves to be more competitive, it is very important for them to rationalize shipbuilding and apply world-class shipbuilding techniques and philosophies. Currently, the TPS and the Lean production principles that have been derived from this system and are becoming accepted in combination with the best practices of world-class manufacturing that build on this technique can offer a foundation for the resurgence of shipyards in the U.S.

An extensive literature review found that a significant shift in production industries from cars to aircrafts, computers, paint, furniture, shipbuilding, construction, electronic devices manufacturing, Cola cans and so on has shown noticeable benefits to the production industry. This trend is a natural consequence of implementing Lean approach, which has been shown to be an effective method many times over. It has also proven effective in a multitude of environments making it different from previous management trends, such as TQM (Total Quality Management), which focused on quality only, while the Lean approach includes cost, delivery and quality (NSCEP, 2008).

3.2.2. Service Sectors

Levitt (1972) is one of the first, among a number of authors, to study the change in principles of organization that adopted to manufacturing series for production lines towards service processes. This study was mainly depended on the concept that the services sector could gain advantage from the methods evolved in manufacturing. Bowen & Youngdahl (1998) conducted research on the shift in Lean production techniques from the manufacturing industry to the service industry through discussing the research of Levitt (1972, 1976) as well as using the advantage of the emergence of the principles of
Lean production that suggested by Ohno (1997). They carried out case studies on Lean tools application and presented the results as a publication of what has recently become known as Lean service. The study highlighted the elements and characteristics of the Lean service applied in a hospital, an airline company and a network of fast food restaurants. The findings of these studies led to further studies by other authors and new applications of Lean service. In order to achieve a better understanding of the development of Lean service in practice, it is significant to determine its origins as well as its evolution and main contributions. A summary of the authors and the titles of their contributions to the Lean service area can be seen in Table 11, which is presented in chronological order.

Table 11: Lean Services Publications

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<tr>
<th>Authors</th>
<th>Contribution Title</th>
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<tr>
<td>Levitt (1972)</td>
<td>Transfer of manufacturing logic to service operations.</td>
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<tr>
<td>Bowen &amp; Youngdahl (1998)</td>
<td>First Lean approach in services with case study and definition of the characteristics of Lean service</td>
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<tr>
<td>Allway &amp; Corbett (2002)</td>
<td>Similarity between the techniques used in manufacturing and services, as well as Lean service principles.</td>
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<tr>
<td>Swank (2003)</td>
<td>Through case study proved that the use of Lean principles could improve performance.</td>
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<tr>
<td>Apte &amp; Goh (2004)</td>
<td>Case study with applications of Lean thinking in information-intensive services.</td>
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<tr>
<td>Ahlstrom (2004)</td>
<td>Presentation of concepts of Lean service and restrictions on their application.</td>
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<td>Author(s)</td>
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<tr>
<td>Venkat &amp; Wakeland (2006)</td>
<td>Use of simulation tools to analyze process optimization in the service sector</td>
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<tr>
<td>Francischini et al. (2006)</td>
<td>Analysis of waste under the customer’s and the company’s perspectives, plus five case studies analyzed.</td>
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<tr>
<td>Abdi et al. (2006)</td>
<td>Establishes that the most important element in the service sector is the human variable. Presenting Lean’s characteristics.</td>
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<tr>
<td>Liker &amp; Morgan (2006)</td>
<td>Using the principles of the Toyota model with an effective integration of people, processes and technology.</td>
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<tr>
<td>Maleyeff (2006)</td>
<td>One of the first models of Lean oriented towards the companies’ internal services and seven wastes in services.</td>
</tr>
<tr>
<td>Arruda &amp; Luna (2006)</td>
<td>Lean principles applied to services and seven wastes applied to services.</td>
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<tr>
<td>Giannini (2007)</td>
<td>Adaptation and Application of Lean tools in back office and front office services, through a case study.</td>
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<tr>
<td>Lee et al. (2008)</td>
<td>The relevance of IT tools, once they support Lean systems during implementations.</td>
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<td>Araujo et al. (2009)</td>
<td>Demonstrated the existence of a synergy between the evidence-based medicine and Lean thinking to the promotion of medical practice quality and efficient process management.</td>
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<tr>
<td>Staats &amp; Upton (2009)</td>
<td>A case study in a software provider that used Lean to improve its operations.</td>
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<tr>
<td>Song et al. (2009)</td>
<td>List of service-oriented Lean tools and each type of service may require different tools.</td>
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<tr>
<td>Julien &amp; Tjahjono (2009)</td>
<td>Presented a case study with the implementation of Lean tools in a Safari Park</td>
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<tr>
<td>Seddon &amp; O’Donovan (2010)</td>
<td>Review of Lean concepts, where Lean has become synonymous with “efficient process”.</td>
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<tr>
<td>Asif et al. (2010)</td>
<td>A case study with several challenges for Lean implementation and reductions in waste, as well as the need to develop specific indicators for services.</td>
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The first attempt at shifting the target toward using the Lean technique in the service sector was made by Levitt (1972). Levitt started the onset of research into the transfer of methods applied in production to the service sector. However, the impact of mass production is still clear in the literature since manufacturing at the time of writing this study had only this focus. In the same direction Allway & Corbett’s (2002) studies proved that Lean services can use manufacturing techniques successfully. Following this line, Lean service results were consolidated by Swank (2003) in order to perform a case study on using Lean in a financial application. While two “toolboxes” for Lean services implementation and a set of Lean tools were introduced by Bicheno (2008) and Song et al. (2009). These tools can be implemented to manufacturing processes but good results can be achieved for the services sector operation if these tools used properly.

Nascimento & Francischini (2004) defined Lean service as a service operations standardizable system that is made up of value added activities that generate value for clients, emphasizing explicit tangibles and targeted at satisfying the price and quality expectations of customers.

Bowen & Youngdhal’s (1998) study highlighted the great similarity between their model and the Womack model as they use pull systems by the customer and generate flow process in services. However, they added another significant contribution by taking into consideration the involvement of the human factor when they proposed the utilization of “empowerment” for teams and employees.

Basically, The service sector is different from manufacturing and production industries because of people’s great involvement whether in preparing goods that should be delivered to a distributor or in a front office (customer service) or even directly to the
customer in the back office (the point of sale). Chase & Apte (2006) reported that manufacturing had only 10% while the service sector in the U.S. had 83% of the workforce. Bowen & Youngdahl (1998), Swank (2003), Sarkar (2007) and Bicheno (2008) studied Lean service principles applied to employees in terms of training or raising their empowerment (autonomy).

Besides focusing on employees, Customer satisfaction is the core part of the Lean service process transformation. The Lean service is different from manufacturing as the customer is the first contact for selling service. Silvestro et al. (1992) categorized the service sector into three different categories: First, professional service with high focus on process, contact time and people such as a corporate banking service; second, so called service shops such as rental or hotel service with medium focus on front office, back office and customization. This service category falls between mass services and professional. The last category is mass service with low attention to customization and equipment; a good illustrative example is the transport service.

Womack & Jones (2005) found out that for a proper use of Lean approach in the service sector, important principles need to be applied, such as working together with the customer in order to ensure that all services operate completely and solve the customers’ problems by providing exactly what the customer wants, where and when they want it, without wasting their time. Two Service laws have been suggested by Maister (1985): The first law compares customers’ service delivery expectations with their perceptions as they become happy customers if the perceived service is better than the expectations. The second service law reveals that the customer’s first impression of delivered service can have an impact on the rest of the experience of service consumption. Based on this suggestion, two fundamental variables can be introduced in the service delivery relationship:

- Customers as the first priority, and
- The workers who perform service delivery.
Abid et al. (2006) stated that the human factor is a highly relevant services sector variable. In service providing operations, manpower is one of the most relevant factors in the cost of doing the job, while high costs and focuses are related to raw materials and equipment in the manufacturing industry.

Although there are similarities between Lean manufacturing principles and Lean service, there is no specific or single model of Lean service that can be considered as reference for any area of service or situation as a standard model. However, there are a number of Lean models that can be implemented based on the nature of service as there is a broad variation in the nature of services such as services related to logistics, air transport of passengers or cargo, information technology, hospitals, food consumption, food production, and so on.

Lately, service delivery organizations such as health care and banking have started adopting Lean methods to meet customer needs more efficiently, and reduce waste in administrative processes and service delivery. For instance, many hospitals across the Pacific Northwest are implementing Lean service methods to the management of hospitals, addressing service processes such as instrument sterilization, supply inventory management, patient appointment scheduling, medical waste management and surgery prep. Virginia Mason Hospital as an example, as part of a strategic four-year plan, has dedicated their service to “Lean thinking,” by implementing Lean production methods to the operation of its healthcare management. This hospital is assessing all steps of processes from the time that a patient waits to get an appointment to the quantity of paper used in offices and patients’ waiting halls to identify possibilities for reducing process “waste” such as materials, waiting, movement, and inventory).

There are other areas such as the financial sector and banks that deserve attention as large volumes of document analysis processing and rework are involved. This is the market area where competition is acting rapidly upon customers and can cause immediate losses or profits. In order to handle such situations efficiently, Lean service principles play a role in continuous improvement, automation, control, agility and ensuring process continuity and stability. The insurance business, similar to the financial sector, has
approvals within its activities and a high processes turnover, and, most probably, this is the reason why Lean service, trying to ensure work process improvement, has been intensively researched within these companies. Table 12 lists a number of the service areas that are using Lean technique in their processes.

Table 12: Areas of applied Lean service.
Lean philosophy has several tools to be used in different situations as mentioned before, so it is important to recognize the applied tools in order to achieve more detail in this research. Table 12 shows the implementation of four tools that are most commonly applied: 5S standardization, value stream mapping (VSM), just in time (JIT) and production balancing (heijunka). In order to evaluate the current state of operation and to suggest further improvements to the process, the first necessary step is to implement value stream mapping to services used in the production process because this step shows clearly all stages in the process of service providing.

A value stream is all activities that add value or not which are needed to produce a product by all flows crucial to each product from raw material to the consumer’s hands as well as the flow of product design beginning from conception to launch (Rother & Shook, 1999). Similar to manufacturing, the application of value stream maps in the service sector is of great relevance, as evidence by the fact that most of the service providing companies mentioned herein applied VSM for process improvement as the service industry is direct involved with preparation, delivery, and development of service
to customers. By using VSM concepts all these steps, activities and processes can be easily mapped.

One of the main pillars and tools of the Toyota Production System is Production balancing (“heijunka”). This tool eliminates high costs and downtime, and results in inventory reduction and efficient use of resources. Balanced operation assists a company to evolve new methods of better team planning, better use of equipment, better purchasing from suppliers, more efficient use of equipment and inclusion of new processes. The previous studies reveal that without balancing production it is not possible to achieve a Just-In-Time system. As examples of production balancing, practical applications in services are seen in financial services (balancing the distribution of the processes of credit approval), in the hospital sector (managing patient flow through surgeries and service) and in the restaurant sector (avoiding delays and disruptions in meal service) and so on.

The third tool is JIT, which is regarded as an effect caused by the implementation of several tools. Slack et al. (2002) considered JIT as a paced technique, targeted at eliminating waste and improving global productivity. JIT is derived as an essential consequence of balanced production. For the customer needs will be satisfied only for what is needed (a pull system which is triggered by demand) and on time. By using JIT, organizations will be able to deliver services to their customers with reduced costs and more efficiency because they will provide just the right quantity, at the place determined, at the right time, and utilize facilities at minimum capacity, equipment, materials and human resources.

Standardization and 5S is the fourth Lean tool often mentioned in the literature. Although the 5S tool may look like something that is already integrated in companies, it is one of the matters companies may not pay much attention to. The 5S tool will ensure that achieved improvement can maintain a stable status. Standardization and 5S can help ensure stability of processes, especially in service areas with high costs associated with mobilizing materials and people. The relevance of discussing these tools is that they are all linked to the Toyota Production System pillars which illustrate that the application of
manufacturing tools should also be applied in the services sector. A summary of tools that have been applied to Lean service is shown in Table 13.

Table 13. Tools applied to Lean service.

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Loyd et al., (2009) implemented Lean tools on unloading operations between major ships and small barges at the Port of Mobile, Alabama and found that the Port has experienced positive results that can directly provide additional capacity, including the ability to handle more revenue railcars (30% increase) and a reduction in barge loading times (125% improvement), barge unloading times (70% improvement), ship unloading times (26% improvement), ship loading times (44% improvement), and train car dumping times (100% improvement).
The Lean Concept has been applied in the service environment; however, the implementation of the Lean concept in the port sector still faces limitations because of higher variations in port processes, and lack of information for port operators on the advantages of Lean implementation.

3.3. Lean Elements

As defined by James Womack and Daniel Jones, the authors of "Lean Thinking", there are five elements of the Lean approach:

1. Specify Value. The definition of Value is recognized by the ultimate client’s needs through tools such as quality function deployment, simulation and value management. In addition, a value-added process is any activity that transforms material/information into a capability for the ultimate client at the right quality and the right time.

2. Map the value stream: drawing a map of all end-to-end connected functions, activities, and processes necessary for transforming system inputs to expected outputs in order to identify and eliminate waste. The value stream identifies all the steps required for a product to be made. Identifying the value stream, the way value is realized, establishes when and how decisions are to be taken by the authorized person. The key method behind the value stream is mapping the process because it will provide a clear understanding of how value is structured into product building from customer’s perspective.

3. Establish Flow: Flows are characterized by time, cost and value. Resources (labor, material and construction equipment) and information flows are the basic units of analysis. Having eliminated waste, make remaining value-creating steps “flow”.

4. Implement Pull: At a strategic level, a pull system identifies the need for product delivery to the customer as soon as it is needed. Customer service “pull” enables just-in-time production by cascading all the way back to the lowest level of the supply chain in production.

5. Work to Perfection: With continuous improvement of processes by a company and with waste eliminated throughout the process flow, perfection is the ultimate reward that can be achieved. Perfection is a high level of customer satisfaction and to achieve such a level means constantly considering what is being done, how it is being done and using the knowledge and expertise of all those involved in the process to improve and change it.
3.4. Lean Tools

The Lean Production approach has 25 tools that can be either totally or partially implemented to improve port performance:

<table>
<thead>
<tr>
<th>Lean Tool</th>
<th>What Is It?</th>
<th>How Does It Work?</th>
</tr>
</thead>
<tbody>
<tr>
<td>5S</td>
<td>Organize the work area:</td>
<td>Eliminates waste that results from a poorly organized work area (e.g. wasting time looking for a tool).</td>
</tr>
<tr>
<td></td>
<td>• Sort (eliminate that which is not needed)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Set In Order (organize remaining items)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Shine (clean and inspect work area)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Standardize (write standards for above)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sustain (regularly apply the standards)</td>
<td></td>
</tr>
<tr>
<td>Andon</td>
<td>Visual feedback system for the yard floor that shows production status,</td>
<td>Acts as a real-time communication tool for the yard floor that draws immediate attention to problems as they happen -- so they can be instantly handled.</td>
</tr>
<tr>
<td></td>
<td>alerts when interaction is required, and advises operators to stop the</td>
<td></td>
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<tr>
<td></td>
<td>production process.</td>
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<tr>
<td>Bottleneck</td>
<td>Discover which function of the process limits the throughput and improve</td>
<td>Enhance throughput by making the weakest link stronger in the process.</td>
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<tr>
<td>Analysis</td>
<td>the performance of that part of the process.</td>
<td></td>
</tr>
<tr>
<td>Continuous Flow</td>
<td>Where work-in-process flows smoothly through production with minimal (or no) buffers between steps of the process.</td>
<td>Eliminates many forms of waste (e.g. defects, waiting time, inventory and transport).</td>
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<tr>
<td><strong>Gemba (The Real Place)</strong></td>
<td>A philosophy that reminds managers to get out of their offices and spend time on the yard where real action occurs.</td>
<td>Encourages in-depth and thorough understanding of real world manufacturing matters by first-hand observation and by talking with the yard employees.</td>
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<td>-------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Heijunka (Level Scheduling)</strong></td>
<td>A form of production scheduling that intentionally produces in much smaller batches by sequencing (mixing) product variants within the same production process.</td>
<td>Minimizes lead times (since each product or variant is produced more frequently) and inventory (since batches are smaller).</td>
</tr>
<tr>
<td><strong>Hoshin Kanri (Policy Deployment)</strong></td>
<td>Align the goals of the organization (Strategy), with the plans of intermediate management (Tactics) and the work performed on the yard (Action).</td>
<td>Maintains that progress towards strategic goals is consistent and thorough – eliminating the waste that results from poor communication and inconsistent direction.</td>
</tr>
<tr>
<td><strong>Jidoka (Autonomation)</strong></td>
<td>Design production equipment to partially automate the production process (partial automation is typically much cheaper than full automation) and to automatically stop when defects are detected.</td>
<td>After Jidoka, employees can frequently oversee multiple stations (decreasing labor costs) and many quality issues can be detected immediately (improving quality).</td>
</tr>
<tr>
<td><strong>Just-In-Time (JIT)</strong></td>
<td>Pull parts through production based on client requirement instead of pushing parts through production based on forecasted demand. Depending on many Lean tools, such as Continuous</td>
<td>Highly effective in reducing space requirements by reducing inventory levels and improves cash flow.</td>
</tr>
<tr>
<td><strong>Kaizen (Continuous Improvement)</strong></td>
<td><strong>Flow, Standardized Work, Heijunka, Kanban, and Takt Time.</strong></td>
<td><strong>Combines the collective talents of an organization to create a vehicle for continuous waste elimination from production processes.</strong></td>
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<tr>
<td><strong>Kanban (Pull System)</strong></td>
<td><strong>Means change for the better. A strategic process plan where employees work together proactively to perform regular, incremental improvements in the production process.</strong></td>
<td><strong>Eliminates waste from overproduction and inventory. Can eliminate the requirement for physical inventories (instead depends on signal cards to show when more products need to be requested).</strong></td>
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<tr>
<td><strong>KPI (Key Performance Indicator)</strong></td>
<td><strong>Way of regulating the movement of goods both within the manufacture and with outside suppliers and customers according to automatic renewal through signal cards that highlight when more goods are required.</strong></td>
<td><strong>Metrics built to follow and promote progress towards critical goals of the company. Strongly designed KPIs can be highly powerful drivers of behavior – so it is significant to carefully select KPIs that will motivate desired behavior. KPIs are frequently used in measuring port performance.</strong></td>
</tr>
</tbody>
</table>
| **Muda (Waste)**                  | **The best used KPIs:**
- Are adopted with top-level strategic
- Are efficient at exposing and quantifying waste
(OEE is a significant example)
- Are readily impacted by yard employees (so they can acquire results)** |

It is a Japanese term that means anything in the production or service process that does not add value. Eliminating muda (waste) is the fundamental focus of Lean manufacturing.
| **Overall Equipment Effectiveness (OEE)** | Framework for quantifying productivity loss for a specific production process. Three categories of loss are tracked:  
- Availability (e.g. down time)  
- Performance (e.g. slow cycles)  
- Quality (e.g. rejects) | A baseline/benchmark provides a and a means to track progress in eliminating waste from a production process. 100% OEE means perfect production. |
| **PDCA (Plan, Do, Check, Act)** | An improvements implementing iterative methodology for:  
- Plan (create plan and projected results)  
- Do (implement plan)  
- Check (verify projected results achieved)  
- Act (review and evaluate; do it again) | A scientific approach will be Applied for making improvements:  
- Plan (develop a hypothesis)  
- Do (run experiment)  
- Check (assess results)  
- Act (refine experiment; try again) |
| **Poka-Yoke (Error Proofing)** | Design error prevention and detection into manufacturing processes with the aim of reaching zero defects. | It is difficult (and costly) to discover all defects by inspection, and fixing defects becomes significantly more expensive at each step of production. |
| **Root Cause Analysis** | A methodology of problem solving with emphasis on overcoming the underlying problem instead of applying quick resolutions that only fix immediate symptoms of the problem. A common method is to inquire “why” five times — each time moving a step nearer to finding the true underlying problem. | Assists to ensure that a problem is truly overcome by applying corrective approach to the “root cause” of this problem. |
| **Single Minute Exchange of Die (SMED)** | Minimize changeover time to less than 10 minutes. Approach includes:  
- Convert changeover steps to be | Enables production in smaller lots, minimizes inventory, and improves client responsiveness. |
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<tr>
<th>Table Cell</th>
<th>Description</th>
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</table>
| **Six Big Losses** | Productivity loss in manufacturing is globally experienced as Six categories:  
- Breakdowns  
- Setup/Adjustments  
- Small Stops  
- Reduced Speed  
- Startup Rejects  
- Production Rejects | Ensures a framework for resolving the most common causes of waste in production. |
| **SMART Goals** | Goals that are: Specified, Achievable, Attainable, Measurable, Relevant, and Time-Specific.                                                                                                                                                                                                                                           | Helps to guarantee that these goals are effective. |
| **Standardized Work** | Captures best practices and documented procedures for production that including the time to finalize each task). Ought to be “living” documentation that is easy to be revised. | Consistently applies best practices for eliminating waste. Designs a form of baseline for future improvement activities. |
| **Takt Time** | The pace of manufacturing (e.g. producing one piece every 34 seconds) that aligns production with client demand. Measured as Projected Production Time / Client Demand.                                                                                                                                                      | Provides a consistent, simple and intuitive way of pacing production. Is simply extended to establish an efficiency goal for the plant yard (Actual Pieces / Target Pieces). |
| **Total Productive Maintenance (TPM)** | A holistic method of maintenance that emphasizes preventative and proactive maintenance to maximize equipment operational time. TPM obscures the distinction between production and maintenance by providing a shared responsibility for equipment that promotes better involvement by workers. In the right environment this can be very significant in |
3.5. Seven Deadly Wastes (Muda)

According to Ohno (1997), Waste can be seen in three major forms:

- Mura or waste due to variation
- Muri or waste due to overburdening or stressing the people, equipment or system
- Muda also known as the “seven forms of waste”

Seven deadly waste categories were identified by Toyota Corporate that hinder the ability to add value into product or service. James Womack and Daniel Jones added the eighth type of waste in their book, *Lean Thinking*, to the seven deadly wastes introduced by the Toyota Company (Womack, & Jones, 2003):

3.5.1. Overproduction

Waste can result from having unstable work schedules and not enough manpower to cover production needs. Additionally, waste occurs when information received is inaccurate, batch size is too large, time is spent on forecasting in areas where there is no demand for services. Circumventing and demanding more than required can also lead to waste. Formally defined, overproduction occurs when more products are made than the customer needs right now. This customer may be an external customer or an internal customer. The reason that overproduction is the mother of all wastes is because it often leads to all the other wastes in one form or another. For example, overproduction multiplies the other wastes such as inventory and covers up problems such as waiting or
variability in demand, and it makes it more difficult to understand the true capacity. Some examples of overproduction are making extra parts to cover for scrap, forecast production, economic order quantity lot sizes, piece rate production, and production done simply to maximize utilization or absorption.

The costs of overproduction include having to deal with the disposition and cost of obsolete discontinued goods which, if not sold at discount or clearance prices, will be disposed of. Overproducing unnecessary items also makes it very difficult to understand the true production capacity, which in turn makes it difficult to make accurate commitments when asked by customers.

3.5.2. Waiting

Waiting is any idle time produced when two interdependent processes are not completely synchronized, for example when the hock cycle for a harbor crane is slower than the number of trucks available. The trucks are kept waiting longer or simply work slowly. Poor man/machine coordination, large changeovers and time required to perform rework cause waiting waste. Waiting in the port operation describes situations when there is idle time created due to lack of readiness of materials, handling equipment, cargo inspection or related information to start the operation. This waste is usually less visible than the others because it is often replaced by overproduction or busy work.

The waste of waiting often directly relates to lost capacity, lost operating costs, and overtime costs since, even though workers are forced to wait from time to time, there is still a rush at the end of the month to get the work done, which often means mandatory overtime. Waiting also decreases the ability to be flexible to changing customer needs and finally, waiting can also create overproduction. If workers have no work to do they may feel inclined to continue producing products or goods that no customer is willing to buy.

3.5.3. Motion

Formally defined, any movement of people that does not add value to the product creates the waste of motion. There are many examples of motion such as reaching for tools or
supplies, or searching for items that are not where they are supposed to be or perhaps searching for items that have simply never been given a permanent home, or straining to reach or lift items off the ground. Waste of motion is any motion of human and/ or equipment that does not add value to the product or service. Wasteful motion is caused by poor workstation layout, leading to excessive walking, bending and reaching, poor method of design for transferring parts from one place to another, poor workplace organization and reorientation of materials.

Motion waste is caused by, first and foremost, poorly designed processes, as they are not designed with the operator in mind. Second, a lack of standard work methods also leads to motion since the work is never done in a consistent way. Third, poor work area layout and design is a huge cause for motion waste. Things as simple as the placement of a community printer can have a huge impact on how much motion, in this case walking, employees are forced to do on a day-to-day basis. And last, but certainly not least, disorganization and clutter are strong enablers of all kinds of waste, including motion. As it turns out, in a disorganized workplace the average person can spend approximately 30 seconds every 5 minutes searching for something. So this is 30 seconds out of a total of 300 seconds, meaning 10% of the total time. In other words, over a 450 minute shift, as much as 45 minutes can be wasted searching for things. Clearly, the waste of motion is a huge productivity killer.

Studies have shown that as much as 30 to 80% of all manual work is nothing but motion, which is why, when SMED (Single Minute Exchange of Die) is conducted or reduction kaizen events are set up, attacking motion is a top priority. And because of all this motion, many companies are plagued with long changeovers, which means they often produce large batches of inventory once they get a machine set-up. The first tool available to address motion waste, and something covered in great deal in the Lean tools explanation, is 5S (Sort, Set In Order, Shine, Standardize, Sustain). Another powerful tool to battle motion is the time observation chart that allows documentation of the detailed steps of a particular process. By doing this we will be able to see where motion has been wasted, which in turn allows it to be eliminated. Another powerful motion fighting tool is a workflow analysis, also called a spaghetti diagram. A spaghetti diagram
is simply a sketch, often hand drawn, of the walking and motion involved in a particular process.

3.5.4. Transportation

Formally defined, the waste of transportation is the movement of materials that adds no value to the product. In other words, transportation is the movement of material using carts, trucks, forklifts, or simply arms and legs. It should also be said that while moving products on a conveyor is not as wasteful as moving material from one disconnected process to another it is still conveyance, a type of transportation waste since conveyors are inflexible and require space and energy. Transport waste is material movement that is not directly associated with a value adding process. Processes should be close to each other and material should flow directly from process to process without any significant delays in between.

This type of waste may be caused by poor layouts, large distance between operations, multiple storage locations, complex material handling systems, large operation batch sizes and working to faster rate than customer demand. Such waste can have significant impact on port performance because it requires more handling equipment and workers as well as damaging the environment by producing more waste and consuming more energy. Among many other things, the waste of transportation often increases the lead-time of our processes due to transportation delays. There are also labor and equipment costs for moving material and people needed to create things such as transfer orders, and then there is the cost of forklifts and trucks, and of course the fuel needed to operate them. It is safe to say that the cost of transportation to most organizations is extremely high.

3.5.5. Defects or Rework

Unclear procedures and unclear specifications waste performance work time which leads to and causes more defects when repeating particular processes. Other reasons for defects include inadequate training of workers, and shortages of specific skills sets, which lead to errors in operation processes. This kind of waste can be seen in port operations. Formally defined, a defect is any work that does not meet the level of quality that the
customer has requested and these defects ultimately plague companies in various ways. While it is very difficult to accurately quantify the cost of poor quality an attempt to measure its impact can be made by looking at elements such as warranty costs, lost capacity, rework costs, field service repairs, and customers lost due to poor quality. The first potential cause is a lack of in process checks. The ability to detect problems early in the process is crucial since the longer a defect is allowed to move through the process the more it costs. Another common cause of defects is low quality material or equipment from suppliers. In fact, some companies spend millions of dollars reworking things like castings before even thinking about adding value that their customer is willing to pay for. Finally, some other causes for defects are inadequate training and poor or no work instructions.

3.5.6. Over-processing

Formally defined the waste of processing, sometimes called over processing, occurs when something is designed in such a way that uses more resources, such as space, energy, or people, than is truly required; sort of like using a sledgehammer to smash a peanut. The waste of processing is definitely the hardest to understand and learn to see since the most common root causes are a lack of understanding of customer needs. A few examples of processing waste are machines that are slower or faster than needed, equipment that uses more energy than needed, for example drilling a hole when simply punching it, which would be much faster, would suffice, completing redundant work such as copying information, doing things just because they have always been done, and cleaning things multiple times.

Over-processing is putting more into the product than is valued by customers who aim to receive only the level of processing that matches with useful and necessary actions. No standardization of best techniques and unclear specifications cause over-processing as do improperly trained employees. The cost of processing waste can be measured by observing the direct running costs such as labor, energy, space, materials, and equipment used to perform the unnecessary process. Basically the cost of processing boils down to the simple fact that people and machines are not adding value as efficiently as they can. By eliminating all forms of processing wastes, things like productivity will most
definitely increase. Completing a workflow analysis or detailed process map in order to identify and remove unneeded steps is another powerful technique used by many companies to eliminate processing waste. This analysis does not have to be done with elaborate electronic software. All that is needed is a piece of paper, a pencil, and someone familiar with the process in question. There are more advanced Lean tools and concepts such as 3P or the product preparation process and value engineering that can also be used to battle this waste.

3.5.7. Inventory

The waste of inventory is any material or work on hand other than what is needed right now to satisfy customer demand. Inventory comes in many shapes and sizes. There is work in process, finished products, supplies, excess documentation, and even unread emails. Inventory waste is stock and work in excess of the requirements necessary to produce goods or services. Unnecessary inventory that accumulates before or after a process is an indication that continuous flow is not being achieved. There are several reasons for excess inventory such as lack of balance in work flow forcing inventory build-up between processes, failure to observe first in and first out, stagnant materials, long changeover time and not adhering to procedures. Inventory is directly related to the cash flow of any production or service company. In other words, if the company is converting inventory into healthy profits, times are likely good from a cash flow perspective but if they have excess inventory that they have already paid for simply sitting on shelves taking up space, chances are their cash flow situation has looked better.

3.5.8. Unused employee caliber

Uneven process distribution, not leveraging the skills of the employees and decisions being made only by the upper authority of the organization, without the involvement of ground workers, are all wastes which should be avoided if an office wants to prosper in the long run. Value Stream Mapping VSM.

• Any work or activity of port operations can be classified into one of three categories: Value-Added Activity: For something to be referred to as value-added three criteria must be met:
1. The customer must be willing to pay for it
2. The “thing” must change in form, fit, or function
3. The work must be done right the first time
If any of these three criteria are missing the step, or process, is not value-added.

- Non-Value-Added Activity.
- Waste or Muda (a Japanese term meaning anything in the production or service process that does not add value from the client’s perspective)

Traditionally, many ports as service providing organizations have attempted to reduce the lead-time or performance of their value stream by eliminating waste from their value-added processes. While this is not necessarily a negative thing, there is far more opportunity in attacking waste or muda. An overview of the customers’ perspective reveals that they expect to receive the most value from port processes while consuming the fewest resources. Lean thinking is the most appropriate approach to identify the value stream from the start of port processes to the end of each individual process and eliminate the steps that create waste (non-value adding). Several ways are available to use Lean methods to improve port processes and programs. Before selecting a Lean method, it can be useful to have an understanding of the initial framework of the development project to easily identify the proper method needed.

It is significant to match organizational goals to the role of a method and to the level of resources required. Figure 6 illustrates how a Lean method is chosen based on the problem being faced. As mentioned earlier in this research, the findings confirm that the process quality dimension is the most influential factor for service quality at the Port of Umm Qasr. Therefore, mapping the value stream and identifying the non-value added activities within its processes is the most appropriate method for process improvement of this selected port. Applying a successful Lean approach depends on the right selection of tools and methods to improve processes.
The first step of a successful Lean transformation is a proper value stream management, which is critical to an organization newly introduced to Lean. Value stream refers to all the steps, both value-added and non-value-added required to take a product or service from raw materials to the hands of a customer. Mapping this value stream provides a visual tool that enables the management to document all required steps from receiving the call for service to fulfilling the customer’s needs and helping operators to observe what
really happens in the service process. There are three steps to be followed when creating a VSM:

3.6.1. Current Value Stream Map

A VSM consists of three deliverables, namely a current VSM, a future (or ideal) VSM, and a detailed implementation plan. The first step in the VSM process is creating a one page current state map. This is a visual diagrammatic interpretation of how the ongoing service process operates, integrating all the information flow steps and components involved in the process. The aim of the current VSM is to draw a simplistic view of the value stream’s current operation mode, permitting the opportunity to define existing wastes. Countermeasures need to be developed to address as many wastes as possible and become the basis for the drawing of the future VSM. A VSM provides an overall observation of the flow of information and materials or equipment across the entire process visible as a dynamic document (Pereira, 2014).

Solutions to reduce port process waste can be identified during Lean events and in daily implementation of Lean principles and tools. Ports need to know how effectively they are operating by measuring how existing processes are performed and categorizing operation steps according to how much value each step adds. Different approaches have been used for data collection in order to map the existing value stream and identify waste within cargo handling operations. A number of port clients were questioned concerning existing port processes for the purpose of mapping the value stream.

3.6.2. Future Value Stream Map

The future VSM is a visual diagram of how the value stream’s processes would ideally operate, identifying waste that is eliminated or greatly reduced in the current VSM, at the end of a planned time period for the planning horizon. Typically, the future VSM is designed on a specific timeline and takes into consideration any changes in the process that are anticipated from the implementation of the desirable improvements by displaying countermeasures as “improvement bursts” Loyd et al., (2009).
3.6.3. Implementation Plan

The final item of a VSM is the implementation plan for the Lean tools, which is the detailed roadmap for a solid recommendation on how to move from the current VSM to the future VSM. Countermeasures that were proposed need to be converted into detailed action components, prioritized, put into a timeframe, and assigned to staff that will be responsible for completing each action component. However, Lean implementation in port services is not an easy approach as it fosters changes in organizational culture such as continual improvement processes and employee involvement in identifying and eliminating waste and problem solving acts (Loyd et al., 2009). Implementing such methodology will result in an operational setting that focuses on rapid performance feedback and leading indicators in order to optimize port performance. Therefore, a systematic implementation of Lean methodology is imperative to attain successful results in any service providing organization and ports are not exempt. Lean should be integrated into the port’s business strategy; investing in training should be undertaken at all port levels, and critical value streams should be managed and identified in different sectors within port departments.

In this chapter, an overview on Lean was presented together with Lean tools and the usage of this approach in the manufacturing and service sectors. Based on the findings of the survey that carried out, the value stream mapping was selected as the proper tools to evaluate the port processes in order to improve the entire operations. In the fourth chapter, the value stream maps of ship entrance, ship maneuvering and berthing, cargo clearance and cargo handling operation processes will be presented. The expected benefits of future value stream maps will be shown as contributions to service cost and time reduction. The main objective of mapping the value stream is to identify the process waste that are not adding value to port customers as well as designing the elimination plan.
4. Chapter Four: Value Stream Mapping to Identify Waste

4.6. Current Value Stream Map

4.1.1. Ship Entrance Process

Before a ship arrives at the outer anchorage area, the agent has to submit a permission request to the port manager, which goes to the port operation unit. In Umm Qasr Port, a compulsory state agency is assigned though most of the ship owner/charterers prefer to deal with a private agency because most of them are global agencies and deliver better services. Therefore, the private agency has to endorse the request letter by the state agency before submitting it to the port authority. The port authority and state agency are in two different places, so the private agent has to travel a distance of about 2 km in order to get this paper signed. The letter must be submitted to the port manager or his deputy to grant permission for the ship’s entrance by ordering the operation unit to issue an official permission to be signed again by the port manager. The private agent needs to deposit cash money that covers the expected fees and charges into the bank account of the port before handing over the letter to the operation unit.

The operation unit will issue two copies of this permission and hand them over to the private agent who must deliver one to the port navigation department (5 km from the port operation office) in order to prepare for ship berthing. The second copy has to be delivered to the pilotage department (65 km from Umm Qasr Port) for designating a pilot (compulsory pilotage) to navigate the ship from the anchorage area to the harbor limit where the harbor pilot takes responsibility for berthing the ship alongside the berth allocated by the port authority with the help of tug boats and a mooring team. Despite the fact that the port authority, navigation department and pilotage department are controlled by one organization, they all act separately resulting in a long process of permitting a vessel to enter the port as shown in Figure 7. When all formalities have been completed by the vessel’s private agent and cargo related permissions issued, the port manager communicates with the navigation department who contacts the pilotage department to navigate the vessel to a berth, subject to availability.

Pilotage is compulsory and pilots may board from a tugboat at the channel’s entrance
while they embark the vessel at the berth before vessel departure. First of all, for a ship to pay the agency fees twice for the same service is illogical without adding any value. Further, the unnecessary transportation for the private agency would be considered as waste in the process.

Figure 7: Current Value Stream Map for Ship Entrance

Another waste caused by this step is the increase in vessel waiting time. Many wastes can be seen during the value stream mapping of ship entrance as follows:

- Processing documents with unnecessary bureaucratic steps, which results in extra transportation between different processes and extra motion within the same
processes.

- Additional costs need to be paid related to double fees for the same service and related to extra transportation.
- Delay occurrences in the offices waiting for the letter to be signed especially when the authorized person is busy with other tasks.
- Communication between the private agent and all other authorities takes place through paper work that results in delays. While most ports today are using modern communications in order to reduce formalities, time and cost.
- Management and decision making structure seems to be very complicated as the letter of permission can be approved and issued either by harbor master or port manager’s office.
- Cargo quality inspection is carried out upon ship arrival and samples have to be inspected by the Ministry of Planning or Ministry of Health and Environment laboratories, which takes at least three days for the results to come out.

Umm Qasr port, like any Conventional Terminal and container Terminal Operating System, requires basic information on Vessel Definition, Yard Definition, and Security Management support to manage this basic information. The private agent through a hard copy of the cargo manifest and bill of lading delivers the required data. The most common requirements are described below:

- Cargo Area Definition
  This is a detailed definition of all cargo operations areas in the port, including warehouse, Container Yard, General Cargo area, Ro/Ro, RoRo-trailer, and project cargo area. The definition shall register terminal resources including handing equipment, yard block/area, warehouse shelf, berth and other terminal facilities. The definitions shall include:
  - Layout view
    - Block information and slot design
    - Facility/ Berth/ Area information
    - Warehouse areas
  - Vessel Definition
Vessel Definition shall register vessel particulars required by the systems. The vessel definition shall include details such as:

- General Particulars
  - Bay design
  - Tank capacity plan and arrangement
  - Longitudinal stress / Cross curve

- Dangerous Goods
  A standardized database and monitoring system for the carriage and transfer of dangerous goods is required to prevent illegal and unregulated transportation of petroleum products and hazardous chemicals. Knowledge of where dangerous and hazardous goods are located on board ship or in port storage helps to prevent accidents and to accelerate search, rescue and containment in the case of oil and chemical spills, fire or explosion.

4.1.2. Ship Maneuvering and Berthing Process

The Marine Operations Department located in the head office of the Iraqi Ports Company manages all shipping traffic within the Port’s jurisdiction. When ships arrive and depart the Port, all must comply with rules and regulations that are established by this department. Therefore, the Port authorities need to be notified on all movement required within the Port area by all ships. The port does not have a by-law guideline to be followed by all ships and provide information on the port procedures like most ports in the world do.

Before a ship’s arrival at anchorage, the ship’s captain must provide all information needed in order for the port to prepare for its arrival. The two anchorage areas are designated by the Marine Operations Department outside the harbor limit. The first one is located 50 nautical miles from the port and second anchorage area is located 6 nautical miles from the port. There are several items related to ship entrance that need to be considered such as water depth (channel and berth), maximum trim restrictions and permissible draught, maximum permissible displacement tonnage or deadweight capacity, maximum ship dimensions (length overall, length between perpendicularrs,
depth breadth overall), maximum air draught, berthing side (port side or starboard side), current and tide restrictions and sea water specific gravity (GCPI, 2016).

The channel leading to the port is provided with a number of buoys following IALA rule A, and the navigation aids department maintains buoyage and other navigational aids to help all ship traffic within the Port of Umm Qasr. The marine operation department is responsible for assigning tugboats to ships requiring assistance for berthing, departure and towage. The responsibility of the Dredging Department is to maintain an adequate water depth throughout the Port and its approaching channel. Likewise, the dredging department and survey department, according to scheduled surveys, will undertake monitoring of water depth. Currently, permanent dredgers are assigned to dredge the channel and waterfront to maintain the required depth. The complexity is the main feature of water tides in the Arabian Gulf, but at the north part of the Gulf where the approaches to Umm Qasr begin, the tides are termed semi-daily irregular with two low water and two high water times every day of markedly different elevations.

According to the British Admiralty Chart No.1238, the tide range at the port and its channel is:

- 0 for Celestial Low Water (CLW);
- 1.0 meter for Mean Lower Low Water, (MLLW),
- 1.9 meters Mean Low Water, (MLW),
- 2.9 meters Mean Sea Level, (MSL),
- 4.0 meters Mean High Water, (MHW),
- 4.6 meters Mean Higher High Water, (MHHW),

These chart readings provide a good indication of a range from MLLW to MHHW of about 3.6 meters and maximum tide range of about 5 meters. On the other hand, the average water depths throughout the channel are about 11 to 11.5 meters at the CLW. This short introduction to the navigational channel and port approach reveals that a ship with a draught of 9 meters and above would need to enter the channel during a specific time and tide. In other words, when the port authority gives the order for the ship to enter
the port, it may need to wait until the water depth is sufficient to avoid grounding problems. This period of delay is causes waiting waste for the ship as the ship may need to wait more than one day when the tide is not sufficient and the ship’s draught is more than 10.5 meters. The availability of sea pilots at the pilot station helps reduce the waiting time at the anchorage area, while on a number of occasions ships are ready to enter the channel but there is a shortage of pilots. Prior to ship arrival, notification schedules would assist port planners in preparing a sufficient number of sea pilots at the pilot station in order to prevent ship delay. The pilot station is located at buoy No.1 to embark the sea pilots onboard entering ships and disembark them from leaving ships. The researcher’s observation and interviews with sea pilots on the status of the pilot station concluded that the maneuverability, safety and living conditions are at a low level compared with the designated tasks. Subsequently, during the rough weather, the pilot station may not be able to embark a sea pilot on entering ships, resulting in increased waiting time. Therefore, a good plan by the pilotage department would avoid this type of waste within the entrance process. Likewise, the availability of harbor pilots, tugboats and a mooring group is important for the reduction of waiting time.

The decision to allow a ship to enter the port depends on the existence of several factors. First, an official request letter from the ship agent asking permission to bring the ship alongside for unloading the cargo is required. The agent must assure that the relevant authorities have inspected the cargo, as proven by an inspection certificate, especially for food commodities imported by the Ministry of Trade. Failing to perform a proper inspection leads to a longer stay of the ship alongside for extra cargo inspection.

The port record indicates that many ships have been berthed for longer times due to inaccurate inspection results, which reduces the possibility of using the berth efficiently and productively. Second, the agent needs to inform the port authority that the cargo has been cleared by the supplier as the financial related issues need to be sorted out before ship berthing. On a number of occasions, the cargo consignee has refused to transfer money before receiving the entire cargo, while the cargo supplier will only release the cargo if the transaction has been completed. Therefore, an argument ensues while the ship is alongside, and 4-7 days may pass before the unloading process commences. Third,
berth availability is the most dominating factor of ship berthing and the commencement of the unloading process. The berth length ought to be sufficient to accommodate the ship according to its overall length. Some ships require a specialized berth such as container handling facilities or a specialized ramp for RORO ships or bulk cargo handling equipment.

In the case that all of the above-mentioned requirements are met then the port manager will give the order for the ship to enter by passing this order to the navigation department. This department is responsible for communicating with the pilotage department in order to assign a sea pilot who will guide the ship. The pilotage department will communicate with the pilot station to designate a pilot who is first in the rotation and whose class allows him to guide the ship according to its specifications, especially its maximum draught. As mentioned earlier, if the water depth is sufficient, maneuvering through the channel begins, and can take 4-8 hours depending on the ship’s speed and tide direction. When the ship arrives at the harbor limit, the task of the sea pilot ends while the responsibility of the harbor pilot begins. The harbor pilot shall proceed by tugboat to the ship before its arrival at the harbor limit. The pilot will embark the ship and berth it alongside the assigned berth with the assistance of another tugboat.

Prior to a ship’s arrival at the port, the harbor pilot requires some information about the ship such as its speed, propeller direction and whether it has a bow thruster and a side thruster. Further, he needs to know if the ship will be using the harbor cranes or the ship cranes to unload its cargo. In the case that ship cranes are to be used, the direction of those cranes will decide whether the ship will be berthed port side alongside or starboard side alongside. The berthing operation is highly influenced by the experience of the harbor pilot, the availability of tugboats, the maneuverability of the ship, the puller pull of the tugboats and mooring team availability.

Sea pilots are a unique team of seafarers who have advanced port channel knowledge, ship navigating skills and ship handling experience. During the time they are on board, the sea pilot’s main role is to collaborate with the bridge crew to guarantee that a safe passage through the channel is achieved. Pilotage is highly dependent on tidal conditions.
and shipping demands, and sea pilots’ work schedules are mostly irregular with pilotage duties carried out across daytime hours. Subsequently, possible stress-related consequences of irregular duty patterns include compromised sleep and domestic and social problems. Furthermore, the long hours of pilotage work, commercial pressures and work under load on board and environmental concerns associated with pilotage tend to increase the pilots’ stress levels.

Mapping the value stream of ship maneuvering and berthing process highlights a number of wastes within this process as listed below:

- Improper ship arrival notification process due to the absence of a proper Port Operation System (POS) in place.
- Insufficient vessel planning process due to the absence of a proper Port Operation System (POS) in place.
- High Level of bureaucracy as all formalities are progressed through paper work.
- Complex decision-making process.
- Water depth and tides increase waiting time for ships with high draught.
- Unavailability of sea pilots sometimes delays ship maneuvering.
- A Number of ports worldwide exempt ships with regular calls from pilotage if the captain is the same, while Umm Qasr Port insists on compulsory pilotage regardless of the frequency of ship calls.
- In case of a shortage of sea pilots at the pilot station, ships entering the port would rely on sea pilots coming from the port on another ship, which means pilots may suffer from fatigue, as their sailing time would exceed 10 hours, especially if the ships’ speed is slow.
- Pilots work irregularity and the quality of sleeping facilities onboard the pilot station contributes significantly to pilots’ sleep disorders.
Figure 8: Current Value Stream Map for Ship Maneuvering and berthing process
4.1.3. Cargo Clearance Process

Currently, there are two steps that must be undertaken by two different customers in the cargo clearance process. First, when the ship arrives alongside, the private agent applies for cargo clearance at the custom office, which will grant permission for the unloading processes to commence, taking into consideration that all cargo documents, such as cargo manifest, are submitted correctly. This permission by the custom office is called the “operation order” and allows stevedoring activities to begin. Normally, this process would require 1-3 hours subject to the submission of the required documents by the agents. However, it may take longer to issue the operation order depending on the type of cargo, port of origin and time of submission. Essentially, this process starts directly when the ship comes alongside and the ship agent meets the ship master in order to collect the required documents.

A good communication system between the ship and its agent will minimize the time required for the cargo clearance process. A letter of operation order request together with other required documents such as cargo manifest, bill of lading and the results of quality inspection would be submitted by the agent to the custom office, ensuring that the expectations of the custom are in line with the delivery of the documents. The Port authority should deliver sufficient resources and qualified staff to carry out the activities/responsibilities throughout the planning stage and work closely with the crew of the ship. To ensure the supply of sufficient resources and qualified staff to carry out all relevant activities with regard to training, qualification and management, an overall working plan and management structure is required. Further, preparing the cargo handling facilities by operation department during the cargo clearance processes and contacting the stevedoring company in order to prepare for the unloading process. During the value stream mapping process, several process wastes have been identified as follows:

- Communication among port authorities and agents performed manually by paperwork
- Cargo detail could be inaccurate and changes can be made on the manifest and bill of lading inside the port premises.
- Extra transportation is required, as the authorities are located in different locations.
- Waiting waste can be identified due to delays in formalities, especially during the night shift.
- Health, Environment, Security and Safety related issues might delay issuance of the operation order when a ship arrives at night for some types of commodities.
- Cargo clearance through paper work instead of EDI system, which would enable the custom authority to quickly analyze the cargo.

Figure 9: Current Value Stream Map for Cargo Clearance process
4.1.4. Ship Unloading Process

The cargo unloading process is considered to be the main production line within port operations, which represents the main function of the port as a node in the supply chain. Obviously, cargo handling differs according to the type of commodity (dry bulk, liquid bulk, general cargo) and how the cargo was shipped onboard ship (bagged, bulk, containerized). The process of handling containers is different from the processes of handling general cargo, bulk cargo, break bulk cargo and RORO in terms of the cargo handling equipment, storage facilities, yard layout and number of employees needed.

Planning the unloading operations prior to ship arrival for container ships is much easier compared with other types of cargo. This is because the customs clearance of cargo inside containers will be inspected within the port storage yard before the delivery of the cargo, while bulk and bagged cargo are normally delivered to the receiver directly onboard trucks. Therefore, the custom authority gives more attention to this type of cargo in order to avoid allowing damaged cargo to pass the port’s border. Container lines make regular calls to the port. As such, the requirements of calling container ships are known by terminal operators in terms of ship configuration, though differences might appear in the number of containers onboard and the loading plans of containers. Consequently, the planning stage of the unloading process can be carried out before a ship arrives alongside through arranging the unloading plan, preparing handling equipment, storage yard and human resources. Pre-berthing arrangements reduce the vessel turnaround time by eliminating the waiting waste, which can be avoided by those arrangements.

The Port planning department would be able to prepare the arrangements if communications with the ship provided data on the loading plan and number of containers onboard as well as other information related to the terminal unloading process. Using EDI assures the safe arrival of data to the port system but this service is unavailable due to the absence of a proper terminal operation system in place. In other words, the container terminal at Umm Qasr Port is unable to benefit from pre-berthing arrangements due to the absence of EDI systems. Therefore, all arrangements are made upon ship arrival alongside the berth and during the period of issuing the operation order. One terminal operator who owns the handling equipment and storage facilities performs the container terminal operations at Umm Qasr Port, while 14 local stevedoring
companies perform the cargo unloading process for break bulk and general cargo. The port stevedoring manager (operation manager) organizes a list of local stevedoring companies as the bases of selection. When the customs authority issues the operation order, the stevedoring manager informs the selected stevedoring company to prepare the requirements for cargo unloading, including the cargo unloading attachments and workers. This step may take time due to the long distance between the port and the city where most of the workers live.

It is worth mentioning that the selection of companies monopolizes the business because the ship owner and cargo owner are unable to make their choice according to the qualifications of the stevedoring company. Subsequently, the service level that is offered by the local stevedoring companies results in a low level of customer satisfaction due to the absence of fair competition among the local stevedoring companies. The main reason for such a poor level of service is the use of the same workers by all local stevedoring companies because they are not employed by any one company. The workers’ lack of skill is caused by the absence of training as the responsibility for developing their skills floats among all the local stevedoring companies. The record of port operations reveals that numerous defects occur during the unloading process due to the workers’ lack of skill, leading to serious cargo damage. Claims from cargo suppliers and ship owners have been received by the port authority as a consequence of damage caused by the workers’ poor skill level.

In addition to the damage to cargo, which has caused an economic impact, the Port’s records also report injuries and deaths of workers due to misuse of cargo handling equipment and attachments. Mapping the value stream for the unloading process has shown serious negligence with regard to safety requirements. Workers frequently perform their jobs without following minimum safety requirements such as the use of safety shoes and helmets. Delays within the unloading process causing idle time for cargo handling have been reported as a consequence of negligence of safety measures. Therefore, waiting waste could be clearly highlighted within the cargo handling process due to lack of skills and negligence of safety measures.
Figure 10: Examples of Cargo Handling Damages
Similarly, environmental awareness by stevedoring companies and their workers has been deemed to be totally absent where some stevedores throw damaged cargo into the sea instead of collecting it aside as stated by ships’ captains letters shown in Annex 1. Dumping of damaged/undamaged cargo directly into the seawater as has shown in figure 10 pictures cause a serious threat to the ecological system as well as reducing the water depth. The VSM revealed that a limited amount of soft gear is available, i.e., nets, wire rope, shackles, slings, lifting bars. It has been noted that additional soft gear is required for cargo handling operations such as attachments. This type of lifting gear should be labeled and certified tested load to be compliant with international regulations that affect operation safety.

Two types of cargo handling operations take place at Umm Qasr Port according to the cargo delivery model. The direct operation includes bulk (dry and liquid) cargo, bagged cargo (rice, sugar and soybean) and steel bars to be delivered directly from the ship to trucks proceeding to the main gate without passing through the storage yards. Normally, the trucks need to be weighed before and after loading by the weighbridge and if the truckload exceeds the standard truckload, another weighing must be undertaken to reduce the truckload. The location of the weighbridge and double-checking of a truckload result in terminal congestion and extra transport waste considering the mismatch between the unloading capacity and weighbridge capacity when double-checking is performed. For bagged cargo, stevedores can manage the truckload easily as the weight of the bags is known yet there are inconsistencies in counting the bags, which leads to overloading. Although the port possesses a huge indoor storage facility that could be used to store the bagged cargo, leading to reducing vessel turnaround time, this facility remains unused due to the direct operation.

The port offers seven days free storage to allow cargo suppliers to utilize the storage facilities in order to minimize the productive time for ships, overcome terminal congestion and reduce transport waste impact. Moreover, unloading productivity is significantly dominated by the availability of trucks regardless of terminal unloading capacity. Historically, port records highlighted delays for ships at the port due to the lack of truck availability, productivity fluctuation and congestion at the main gate for the inbound/outbound trucks. Productivity consistency enables the port operation planners to
estimate the required capacity to handle the total throughput efficiently. Fluctuation in cargo handling productivity requires extra capacity to be secured in order to accommodate calling ships, which results in increasing terminal inventory waste and leads to over processing waste by using more resources as well as overproduction waste during normal productivity. The inconsistency in cargo handling productivity compels the terminal manager to request more trucks than the operation requires to maintain continuous operation. The extra trucks require more space within the port facilities, which might interrupt the operations.

Containers, vehicles, general cargo and RORO cargo follow indirect operations wherein cargo is unloaded from the ship to the terminal trucks and transported to the storage yards. Terminal productivity depends on gantry crane/harbor crane productivity, number of ship to shore cranes, number of terminal trucks employed, distance between the ship and storage yard and the availability of handling equipment. The lashing and unlashing of containers could have significant impact but it is carried out before starting unloading operations for unloading containers and after completing empty container loading. The utilization of the storage yard illustrates that the indirect operation minimizes vessel turnaround time. The main reason for the advantage of indirect operations is the successful factors of operation efficiency controlled by the port authority by providing resources to handle ships. This is in contrast to the direct operation, which mainly depends on the availability of external trucks to transport imported and exported cargo.

The direct operation can be more effective if the train, which is linked to all berths, is efficiently used to carry the unloaded cargo from the ship to the train wagons directly. The train can carry only a small portion of the unloaded cargo, relying on the limited capacity of existing railway services. Moreover, the condition of the existing trains seems to be unreliable for efficient operation within the conventional control system. The port layout has been modified over time according to the needs and terminal purposes without changing the railway lines within the port, which makes train access difficult. Increasing cargo import through the port would reveal the potential of involving the railway transport mode in reducing congestion, which indicates that serious attention needs to be paid to the entire railway transport system.
The existing storage capacity of both closed and open storage facilities is deemed to be sufficient to accommodate different types of cargo during normal conditions, while the cargo clearance process affects the delivery process duration that requires extra storage capacity, especially at the peak period of port operation. The port layout has direct influence on the distance travelled by terminal trucks to move cargo between the ship and the storage yard causing extra cost, time, and energy and generating more greenhouse emissions. Efficient utilization of storage facilities and shorter distances between the berth and storage yard eliminate transport, motion and waiting wastes.

The cargo delivery process commences when the consignee prepares to receive the cargo by preparing the necessary documents to be presented to the custom authority in order to clear the cargo for delivery. The consignee begins with the private agent who will provide a delivery order with all details related to the cargo such as type of cargo, volume, origin, name of the ship, voyage number and date of arrival. The consignee needs to pay fees for the delivery order according to the agency pricing system which is different from one agency to another. The delivery order of the private agency alone is insufficient to be processed by customs. Instead, the consignee needs to receive another delivery order from the state agency with payment of another agency fee. The delivery order is submitted to the custom authority in order to start the process of cargo clearance for final delivery. The custom authority informs the consignee to load the cargo onboard the truck for custom inspection as the custom officers normally inspect the cargo on the truck. Such inspection practice causes congestion inside the port due to the time required for the formalities after the customs inspection, while the cargo remains onboard the truck.

Most international ports allow cargo to be inspected in the storage yard then issue a cargo clearance certificate that allows the cargo to be loaded onboard a designated truck and delivered to the consignee. The advantage of this cargo clearance practice is to prevent the congestion of trucks inside the port area waiting for documents to be finalized by the custom authority. The port record for the indirect operation indicates that the average time for a truck to pick up a container from the gate entrance to gate exit is 8 hours, while it takes more than 24 hours for a truck inside the port to load general cargo such as construction materials, heavy equipment, or furniture. Considering the number of
trucks waiting inside the port, it is obvious that the port authority needs to provide more effort to activities other than cargo handling such as cleaning facilities, traffic control system, security control and provisions for truck drivers. Basically, the added efforts would be adding more costs to the operation cost, which would either increase the port tariff to be paid by the customers or lower the port profit.

Figure 11: Current Value Stream Map for Cargo Unloading process
During the value stream mapping for cargo unloading process, a number of wastes were identified:

- Planning for prior ship arrival deemed to be difficult due to the inaccuracy of cargo documents especially for containers.
- Skills of stevedores causing cargo damage and threat to safety.
- Poor operation planning causing the utilization of more port resources.
- Long distance between the unloading process, storage process and delivery process.
- Poor periodical equipment maintenance leads to frequent equipment failure during the cargo handling process.
- Skills in handling harbor cranes and gantry cranes need to be enhanced through intensive training courses. The training plan is a key part of the operation and employee readiness is crucial for efficient operation process.
- Crane productivity, yard transfer productivity and delivery productivity unevenly performed.
- Low level of compliance with safety and security measures due to terminal focus on mixed cargo and mixed operations establishing a high-risk environment.
- Absence of a wider business improvement program involving performance evaluation and measuring the customer service level.
- Complicated decision-making process in relation to cargo handling process resulting from complexity of management structure.
- The berths and storage yards need to be cleaned and roads require continuous maintenance, as there are many obstacles to smooth cargo flow.
- Large gap in communications and knowledge sharing between the operation management and ground workers leads to unused employee capacity.
- Cargo inspection process delaying the cargo unloading process and cargo delivery process.
- Difficult gate control process due to delays in custom formalities and inspection allowing more trucks to enter to the port.
- Most cargo clearance certificates are issued between 14:00-17:00 pm. As a consequence, most trucks would be found at the gate at the same time, resulting in a bottleneck for cargo flow.
Ø Absence of TOS implementation encourages corrupt people to tamper with the system.
Ø Calculating the port charges and billing system might delay ship departure or cargo delivery.

4.2. Future Value Stream Map
4.2.1. Ship Entrance Process

In the past, business competition was not intensive. Management could wait to get enough information, before making a decision. In today’s transportation industry, real time information is considered of high value, as it can maintain the organization’s competitiveness. If a port obtains information quickly and precisely, the management can quickly and precisely make decisions and/or solve problems. Today’s port operation is a system of highly interdependent assets comprising of: trucks, cranes, warehouses, quay, yard, computer systems (tangible assets); knowledge, operating procedures, brands, relations, partnerships and customers (intangible assets); and human resources, all working together and to meet the same purpose. Due to the considerable amount of information in a port operation, the vast majority of ports and other cargo operations utilize relatively advanced IT systems to manage the information, enabling end users and management to quickly and easily process the information required to efficiently manage the port operation.

Ports and Shipping today cannot operate effectively without comprehensive Information Management Systems. These include Automatic Identification Systems (AIS), Vessel Traffic Service (VTS) and Port Operating Systems (POS). Such systems, when combined with a Port Community System, acting as the hub, are able to offer a wide range of advantages to the transport sector in Iraq by improving the efficiency and productivity of port operations. The benefits of these improvements pass not only to port operators but also to port customers, including shipping lines, freight forwarders, and shipping agents. At the national level, the entire Port community and those who depend on it can benefit from the provision of an enhanced and economic logistical chain for international shipping.
Port Community systems, at the national level, can provide logistical chains, which improve the coordination and cooperation of land transport, maritime transport and port operations in the region. By linking all members of the port community together, the network system is of benefit to customs authorities, police, immigration, Ministry of Public Work and Transport, Ministry of Commerce, and many others.

At the regional level, a comprehensive Port IT System will maintain data on ship arrivals, cargo quantity and nature, channel maintenance, customs, and other vital information that is in an electronic format and that can be exchanged with other ports in the region. This exchange of data will make direct cooperation between ports and land transport more efficient and professional, and will also be a method for promoting further cooperation in the entire transport sector.

For Umm Qasr Port, the benefit of implementing a comprehensive and integrated Port IT system includes less paperwork, less time and effort spent, better decision-making, reduction of unnecessary cost, increased productivity, fewer errors, and an increase in overall satisfaction for the port’s stakeholders. Implanting a successful Lean culture within the port business requires a smooth information flow to eliminate the wastes that occur due to bureaucratic management practices. There are no negative social economic, cost, or environmental impacts foreseen from Lean implementation. On the contrary, the project will improve the commercial operations of Umm Qasr Port for all players in the transport sector. A modern port management and communication system will enhance shipping safety, and promote faster and more efficient movement of trade with low cost and greater reliability. The country's international trade competitiveness will, as a result, be increased.

As the implementation will enhance the management system for dangerous goods and waste management, it will improve the environment in the port and in the harbor areas. Figure 12 suggests a new value stream map for the ship entrance process through modifying the flow chart and combining a number of steps to be performed by one agency rather than duplicating tasks with extra resources, cost and time consumption. Restructuring the decision-making process by eliminating unnecessary steps would improve the ship entrance process by eliminating the waiting waste and transportation waste.
Figure 12: Future Value Stream Map for Ship Entrance
4.2.2. Ship Maneuvering and Berthing Process

In order to introduce the future VSM for the ship maneuvering and berthing process, the port authority needs to create a central cluster system, which in its first version should include the following main features:

- Elimination of double reporting to authorities.
- Radical streamlining of collaboration with shipping lines, agents, and other stakeholders in connection with ship calls.

To achieve this, a comprehensive, integrated web-based Port Management Information System (PMIS) is required. This provides real time on-line access to the full range of operational vessel information for ship owners, agencies, vessels, service companies and government bodies using web portal technology. This includes the following:

- Overall platform and Interface: Managing overall PCS and integration
- VCS (Vessel Clarence System): Handling Vessel information
- MSS (Marine Service System): Handling marine services
- CMS (Cargo Management System): Handling vessel cargo information
- Report Statistics

Platform

The central cluster system shall adopt a globally proven platform to provide rapid development, various features, secured system, reliable interface, and a well-organized system.

VCS

The VCS shall provide an extensive single-window electronic vessel clearance system, allowing all related parties to handle paper work at a glance.
MSS

The MSS shall support the harbormaster in optimized marine services such as pilotage, tug, mooring, fresh water, bunkering, and private boat.

CMS

The CMS shall function as a management application to ease operation of cargo handling service such as balancing, import, export and carrying out the abundant paper work involved.
VMS
The VMS shall provide a real-time vessel movement trace at a glance and anytime, and store history of vessel movement.

Interface
The data interface shall provide a real-time and flawless system interface for areas such as planning, operation, management system, and finance and accounting. Thus, as users perform activities, the results shall be transferred and captured in relevant systems, including the finance and accounting system, to avoid users wasting time as waiting waste to reconcile the operation results.

Benefits to be provided for the port users
The new value stream process provides the port community with a fast and cost effective way to deliver economical and efficient service to clients before, during and after the vessel’s port call. It would also boost the productivity of all port-related administration. In this way all parties in the port community can obtain immediate returns on their investments through operational efficiencies. A shorter process of ship maneuvering and berthing would be performed due to the elimination of waiting time impact and accuracy of reported data.
4.2.3. Cargo Clearance Process and unloading process

This research suggests three modules to be used for port operations in order to reduce waste impact on port processes and mapping value stream for operation processes. Prior to ship entrance, the port operation department should prepare berth planning, yard planning and ship planning as follow:

4.2.3.1. Container Terminal Operations

A. Planning Modules

- Berth Planning
Berth Planning shall allow for planning all resources put into terminal operation, such as berth and gantry cranes. It shall assign berth locations for vessels making a call to the terminal. This process shall help planners to find optimum berthing positions, taking gantry crane coverage and maintenance schedule into consideration. Gantry Crane Planning shall assign numbers and types of quay cranes for vessel operations, and shall allow for an automatic long-term schedule creator that reduces effort and time in vessel schedule registration work. It shall have the following features

- Vessel schedule maintenance
- Graphic berth plan interface for vessel length, berth number, and time span.
- Berth status checking and warning message
- Simulation of Berth Allocation
- Dynamic change the berth graphic by changing the data from the vessel schedule database
- Resource Management
- Inquiry & Reports

- Vessel Planning

The vessel-planning process shall plan vessel loading and discharging operation. It shall include the following features:

- Crane assignment (Auto/Manual)
- Loading Profile (Auto/Manual)
- Detailed stowage checking and warning message
- IMDG insulation checking and warning message
- For transhipment vessel, ship planner can make the stowage plan without the actual container in the yard according to the discharging container information
- Stability
- Tool, inquiry and reports

- Yard Planning
The Yard Planning module shall allow planning of yard space for all containers carried into the terminal from land and sea gates. The yard planning shall address major bottlenecks to improve productivity and shall maximize yard stack capacity with optimized yard plan functions for export cargo, import cargo, transshipment cargo and remarshaling operation. It shall include the following features:

- Outbound / Inbound Planning
- Remarshaling Planning
- Inquiry and Reports
- Yard overview filter by POD, vessel, container owner, container type, etc.
- Yard status checking and warning message
- Multiple and real time query function for a specific container or a specific plan
- Alert for non-matching containers
- Dynamic active/ inactive plan
- Classifying the container attribution by color

B. Operation Modules

The Operations module shall include the modules/functions listed below. All these modules shall be tightly integrated, in real time, with each other as well as with the Planning and Management modules. The Operations Module shall control and monitor all the movement in the terminal in real time with a wireless communication solution. The operations module shall include the following features:

- General Features
- Support monitoring
- Job order
- Job control
- Problem solving
- Integrated alerting
- Yard/Ship Operation
- Operation Monitoring
- Yard Control
- Quayside Control
- Traffic Control
- Yard monitoring (Graphic with alert features)
- Gate house monitoring with alert features
- Equipment control and real time monitoring
- Graphic work queue assignment
- Hand-held interface (Gate house/Yard/Quay)
- Yard and Vessel automation
- Real time searches for yard status, loading status, truck and equipment operations

- Gates
  - Yard position auto assignment by yard status and container attribution
  - Gate data processing, gate in instruction and EIR
  - Manage 2 way truck instruction such as 2 containers in-gate and 2 containers out-gate, up to maximum 4 containers
  - Manage different seal type
  - Manage damage container assignment

- Reefer Monitoring
Reefer Monitoring System Interface: The interface with the reefer monitoring system shall provide the reefer status information (fault information of reefer) for the operation system in real time. This interface shall enable the terminal to guarantee non-stop reefer status monitoring.
  - Container Number, Yard Location (Block, Bay, Row, Tier)
  - Setup Temperature (Celsius, Fahrenheit), Current Temperature (Celsius, Fahrenheit)
  - Plug-in/out time, Air Vent (%)
  - Vessel Voyage Description (Vessel Code, Calling Year, Calling Sequence)
  - Size and Type, Cargo type, Job Type, Import/Export
C. Management Modules

The Management module shall perform analyses of results of planning and operation, and shall manage container-handling operation related to billing and inventory, and equipment maintenance. The sub-modules shall be tightly integrated, in real time, with each other as well as Planning System and Operation System.

- Statistics and Reporting

The Statistics module shall support the Decision-Making process by providing

- Statistical information on historical moves per each individual item of equipment and equipment type
- Equipment productivity of each individual item of equipment and equipment type
- Exact data on performance of each job order execution, including equipment ID, execution time, performance time, pick up position and set down position, delivery to and from (truck, vessel, rail, customs).
- Statistic and Performance Analysis data, as well as KPI analyses, document and sales/marketing statistics, report summary and various charts

- Billing

The Billing module shall maintain an accurate account of terminal operation, where users shall be able to manage various kinds of billing codes with tariffs or special contracts as well as business partners and easily issue invoices for Umm Qasr Port partners. Payment confirmation shall also be controlled. The Billing module shall include the following features:

- Code management such as tariff code, invoice unit, and demurrage.
- Data gathering on terminal operation
- Invoicing for credit
- Receipt for cash
- Payment summary
4.2.3.2. **Conventional Cargo and Ro/Ro Operations**

A. Planning Modules

The planning process shall provide optimized allocation of equipment and human resources and supports the management of berth and warehouse space. It shall also manage the process of paperwork (Documentation):

- Berth (and if applicable) Warehouse Planning

Berth and warehouse planning shall arrange the approval of vessel berthing, considering agency credit, and make a plan for efficient berth/warehouse allocation and occupancy. It shall have the following features:

- Realize optimum berthing position considering equipment coverage and cargo type and facilities (warehouse, conveyor).
- In case of warehouse planning, it needs to provide a function by which the warehouse supervisor can adjust the quantity of equipment requested by an agent.
- Estimate precise working and vessel departure time by cargo volume and type.
- Find the visual layout of warehouse planning by cargo details.
- Easily make a plan for vessel berthing and warehouse storage via simple mouse click.

- Workforce and Equipment Planning

The roster planning shall perform booking of work force and equipment for cargo operation, as well as deploying equipment and human resources to the workplace.

- Document Management

The document management shall prepare all necessary documents for import and export cargo based on the amount and delivery modes, and shall issue slips for gate in/out. The document management shall include the following features:

- Conflict prevention between agent and operator by recording specific delivery mode, information modifier and transporter
- Enable efficient operation management by inputting cargo types, amount, delivery modes and expected cargo arrival and delivery time according to B/L and S/N (Ship Note)
B. Operation Modules
The Operations module shall provide real-time cargo operation and manage warehouse storage. It shall also control the work processes of work force and equipment and handle vessel shifting, vessel crane operation and double banking.

- Vessel Operation (Discharge and Loading)
The vessel operation module shall have hatch and loading/discharging operation, and shall manage delay operation. It shall have the following features:
  - Manage the damaged cargo categorized as loaded, returned and replaced
  - Control the amount of shut-out and spare cargo
  - Inform the over-landed and short-landed for import cargo
  - Prevent cargo loss by recognizing detailed cargo flow easily
  - Guarantee work transparency by loading operation of agent instructions

- Warehouse/Gate Operation
The warehouse/Gate Operation module shall manage handling in/out and gate in/out, and shall support warehouse reconciliation and movements in the warehouse. It shall have the following features
  - Handle the warehouse operation to the level of assigning cell units, considering readiness of vessel and delivery transportation
  - Change cargo amount and condition: normal, damaged and shut-out
  - Plan and operate stacking and un-stacking
  - Confirm the permission from customs for Gate In/Out

- Rail Operation
The Rail Operation shall provide functions of train schedule, rail booking and rail confirm loading/discharging. It shall have the following features
  - Manage cargo operation at the unit of wagon, based on train schedule
  - Alert overweight cargo
  - Prevent cargo loss by easily recognizing detailed cargo flow
  - Guarantee work transparency through comprehensive rail information

- Ro/Ro Operation
The Ro/Ro Operation module shall provide functions to make a plan and operate Ro-Ro based on manifest information. It shall have the following features:
  - Manage a level of motor vehicle's accessory
- Possible to control the operation by customs permission
- Estimate the volume of an operation using manifest and pre-advice
- Provide motor vehicle planning
- Confirm vessel operation
- Confirm yard operation
- Perform gate in/out

- Container Operation
The container operations module shall provide functions to operate containers with detailed information such as container number, type, and size. It shall have the following features:
- Enable accurate operation of containers
- Possible to manage special types of containers such as reefer
- Estimate the volume of operation using manifest and pre-advice
- Gate in/out
- Quay side job control
- Yard job control

- Resource Operation
The Resource Operations module shall set shifts for stevedore/trimming workers, and manage actual working time of workforce and equipment. It shall include the following features:
- Cargo handling by cargo handling equipment
- Input of all necessary operation data for automatic calculation of billing
- Possible to modify all inputted operation data
- Automatically generate data of staff working time and allowances
- Guarantee work transparency by registration of manpower and equipment from agent

- Special Operation
The Special Operation module shall support vessel shifting, double banking, ship-to-ship operation, cargo shifting, and re-handle operation. It shall include the following features
- Double banking (to support “ship-to-ship” operation)
- Provide berth planning and actual operation data for vessel shifting by agent requests
- Support double-banking by banking type and STS operation
- Manage the changed vessel operation and return to shipper operation for damaged and shutout cargos.

C. Management Modules
The Management module shall provide relevant information and produce reports on analysis and forecasts. It shall also handle information on business partners, various tariffs, and contracts, measure work performance, and produce management information based on combined operational and financial analysis.

- Operations Monitoring
Operations monitoring shall manage all basic information such as equipment, commodity and codes, so that users are able to check the detailed progress of all operations. It shall include the following features:
  - Possible to configure all codes used in screen
  - Enables application of code changes to system without changing source codes
  - Handle the detailed information of loading/discharging/handling in/handling out
  - Manage the overall progress of all terminal operations

- Statistics and Reporting
The Statistics module shall support the decision-making process by providing
  - Throughput statistics by cargo type and commodities
  - Throughput statistics by shipper and consignee
  - Import/ export detailed monthly throughput
  - Vessel number and GRT by cargo type
  - Local/ foreign trade vessel throughput by import/ export
  - Local and foreign vessel type throughput by import and export
  - Total cargo throughput by port
  - Total cargo throughput by the type and port
  - Commodities loaded by type and port
  - Commodities discharging by type and port
  - Total number of ships calling by port
  - Type of ships calling by port
  - Vessel origin/destination by country and port

- Billing
The billing module shall provide data gathering, operation data reconciliation, (possible) invoicing and proof sheets. It shall include the following features:
- Provide availability of all tariffs, rates and special contracts with business partners
- Issue service charges in detail, bill tabulation, and payment instruction
- Invoice service charges with inputting of various charge codes
- Enter details of invoice, issuing credit slip, managing collecting and outstanding
- Analyse trend of sales & turnover

In order to take advantage of the efficiency enhancing features in those modules it is necessary that the operations organisations are aligned for these processes. The major changes seen as necessary at the Port at this time are:

- Centralizing all planning functions (road/rail, vessel, and yard) into one department/office. There are many reasons for centralizing the planning functions, some of which are:
  - Higher utilization of planning staff and better skills, which will be required in dense stacking areas and with higher throughput terminals
  - The planning of e.g. road/ rail cannot be carried out independently of yard, gate and vessel as they share the same equipment, labour and yard handling areas
  - Equipment pooling requires that all activity areas in the port are controlled by the operations and planning department.

Note that contrary to the current practices, the functionalities inherent in applying Lean approach and a standardized IT system will assist the planners in achieving higher equipment and yard utilisation.

- Dedicated equipment dispatchers monitoring and controlling the operation.
- Centralise and move all cargo documentation, cargo clearance and cargo release functions in one department/office, as close to the truck gate area as possible.
Figure 14: Future Value Stream Map for Cargo Clearance process
4.3. Time Factor or Takt Time

4.3.2. Takt Time Introduction

In a port transport system, customer demand may be defined as the essential requirement to move cargo from one point to another within a time window. To satisfy customer demand, this demand needs to be well specified and determined by the port operation unit. The demand for maritime transport increases annually all around the world and many countries have taken initiatives to increase their ability to handle more cargo at their ports. Nevertheless, vessel turnaround time (VTT), which is an important indicator of the quality of the service and efficiency of a port, is still considered a dominating attraction factor. Oram and Baker (1971) express the importance of vessel turnaround time as “no single cause more directly affects the cost of living of a maritime country than the speed with which ships are turnaround in her ports”.

Port users consider vessel turnaround time (VTT) when they select terminals to call. They are highly sensitive towards the time taken to complete operations in each terminal as shipping lines earn revenue only when ships are in the sea. Further, a time saving of 10 minutes from a single terminal would make a huge impact on time and cost saving in total supply chain in the world. Hence, almost all the port users first look for a terminal that is capable of providing high quality and efficient service with minimum VTT rather than looking for low cost terminals. The average VTT is the port capability illustration on how efficiently handles goods movement at the terminals and beyond. It can be defined as the average time a vessel needs to be alongside in a port (difference between time of entry and departure).

Many previous studies have focused on areas related to improving terminal performance by reducing VTT from the operational capability. A number of researchers have pointed out the factors that affect the VTT and their significance for VTT in relation to customer demand. However, the significance of these factors, the contribution of each factor to vessel turnaround time and whether these factors are within the control of the terminal operator or beyond has not been discussed concerning container terminals in Iraq. Further, few studies identify how customer demand is measured in the port of Umm Qasr. Most demand for port services is a derived demand that depends on the demand for freight at a destination. Therefore, ports are only a single component in a network of
services that delivers the outcome of the movement of goods and people. Large-scale transport of goods is one of the foremost functions that ports facilitate. In order to meet the demands resulting from the dramatic expansion in maritime transport in recent decades, flexible and fast exchange of information between individual ports and throughout the whole logistics chain has become a key factor. Supply chains today need to be supported by a wide range of advanced communication tools and high capacity, reliable, cost effective transport networks. The role of Ports as inter-modal distribution centers has become crucial to the cost reduction and reliability of the whole logistics chain. Shippers and carriers select individual ports not only based on their cargo handling but also on the Added Value Logistics services offered. Hence, this paper attempts to calculate the Takt Time and cycle time of port operations to identify critical factors affecting VTT and their significant relationships with respect to the multi-functions of the Port of Umm Qasr, by taking service type into consideration. Thus, the findings of this research will be helpful to terminal operators to optimize their current performances, while identifying both controllable and uncontrollable factors that affect Vessel Turnaround Time.

Takt Time is the ultimate allowable time to meet customer demand; Takt Time is the pace/rhythm by which a product/service is produced/Performed and must fall within the Takt Time or set equal to the Takt time; if not, then there will be unfulfilled customer demand. This research provides an example of how Takt Time can be used in a service-type operation (port operations) and illustrates how else it might be used outside of manufacturing processes. For a port process that is supposed to deliver a high level of service quality, the time spent providing such service needs to be value-added time, transferring the goods in a way that the customer is satisfied with and willing to pay for. Lean principles identify the wastes within the service delivery process through mapping the value stream of port operations so that the time used for processing these wastes is defined as non-value adding time. In many ports, customers are charged according to the delivered services, including the non-value added steps, because the port services providing follow push system while the Lean concept emphasizes setting up the port system on a pull bases as customer demand is the main source of port planning.
4.3.3. Literature Review

Compared to port efficiency and productivity studies, a port effectiveness-focused approach was not widely considered until the middle of the 2000s. In port/terminal operations, effectiveness may denote that desired results (i.e. service) are delivered to port stakeholders (i.e. customers, government, regulators, providers and other entities) who may have different performance objectives. In other words, different stakeholders’ perspectives should measure port effectiveness. Brooks (2006) noted the importance of combining efficiency research with effectiveness for port performance measurement. Brooks and Pallis (2008) developed a conceptual port reform performance framework integrating various relevant port performance indicators under existing port governance models. Brooks et al. (2011) investigated port users’ (three user groups of carriers, cargo interests and supplier of services) needs with the extent to which criteria are important to them in terms of the services received and how they evaluate port effectiveness. Brooks and Schellinck (2013) examined the importance-performance gap based on divergence between performance effectiveness and user expectations, and looked for guidance on how to use the data collected from the users in identifying and prioritizing investment for improvement efforts. With changing environments affecting the role of ports, studies of port performance measurement have been conducted by focusing on port-centric logistics as moderators and their integrations in the supply chain (Marlow and Paixão Casaca 2003, Bichou and Gray 2004). Over time, the concept of ports has been redefined in terms of their functions, geographical scopes and activities (Notteboom and Winkelmans, 2001; Paixão and Marlow, 2003). Hence, ports have been continuously adapted to the evolutionary changing environment to sustain themselves in highly competitive environments. Numerous studies have introduced conceptual frameworks and dealt with port evolutionary changes such as supply chain integration, Lean/agile perspectives, customer-oriented practices, and value-added activities (Marlow and Paixão Casaca, 2003; Bichou and Gray 2004; Bichou, 2006; Langen et al., 2007; Panayides and Song, 2009; Woo et al., 2011; Brooks and Schellinck, 2013; Woo et al., 2013). However, they suggested either conceptualizing the framework without empirical research or validating correlations between the issues and port performance on partial dimensions.
Numerous methodologies have been applied to measuring port performance. They vary from a heuristic method to a mathematical model. The methodologies applied include a heuristic approach to identifying performance indicators (Brooks, 2006); technical and economic efficient equations (Talley, 2006), parametric or econometric approaches, such as a cost or a production frontier function (Gonzalez and Trujillo, 2005); a stochastic frontier analysis (SFA) (Cullinane et al., 2002); a non-parametric approach such as data envelopment analysis (DEA) (Cullinane and Wang, 2006); a confirmatory fact analysis (CFA) and structural equation modeling (SEM) (Woo et al., 2011; Woo et al., 2013); and an importance-performance gap to investigate perception difference between ports and port users on PPIs (Brooks and Schellinck, 2013). However, the literature tends to focus on limited dimensions or specific areas of ports/terminals and not on ports as a whole.

Some of the factors that affect VTT are more important than others and have more potential to speed up or slow down the turnaround process. Identifying the influence level of each factor would cater to improving performance through effective intervention in the short term as well as the long term. There are differences within terminals of the same port such as ownership, organization structure, geographical position and approaches to management. This will lead to dissimilarities within terminals, and how the critical factors towards VTT are managed. Influence levels of these factors compared across terminals could be used to analyze such differences.

Notteboom and Winkelmans (2001, p.83) claimed, “Seaports that will succeed in the 21st century will be those that are 'customer led' who really understand customer needs and who can offer 'best-in-class’ performance”. Among port choice factors from the perspective of shippers, customer service level is measured by including port rates, customer services, claims handling, equipment availability, flexible schedules and financial stability (Bagchi, 1989) and customer service level is a major aspect of creating competition (Nir et al., 2003). Customer service care, which is the factor in our model, is analogous to customer service level. Tongzon (1995) found that port users are more concerned with indirect costs associated with delays, loss of market share, loss of customer confidence and opportunities foregone due to inefficient service, than with port charges. The implication is that ports need to be more concerned about customer care—that includes offering cargo owners reliable information on cargo at port at all times and
24 hour surveillance over vessel berths in the port. These will also lead to port choice
decision of shippers and shipping lines.
The fragmented approaches may fail to take into account all related issues encompassing
the ports, indicating that more studies are needed to overcome the shortcomings. On the
other hand, previous studies on port performance generally take into account the Port
Performance Indicators PPIs, mostly from the port planners’ perspectives, with a focus on
seaside operations. Further, the PPIs measure the operations performance by determining
the ship operation, yard operation, storage operation and gate operation separately. In this
regard, a new time measure using the Takt time and Cycle time of port operations is
suggested, taking into consideration customer demand as the core of port business.
This study is the first research conducted on the situation of Umm Qasr Port in light of
turnaround time by using the Lean approach and more specifically the Takt time as well
as how turnaround times are determined.

4.3.4. Takt Time, Cycle Time and Lead-Time

In the Lean System, the maximum amount of time in which a product or service needs to
be produced or delivered in order to satisfy customer demand is called Takt Time. The
term Takt comes from the German language, which means “pulse\pace\rhythm.” Set by
customer demand, Takt generates the pulse or rhythm across all processes in a production
or service business to secure a continuous rate of flow and utilization of capacities (e.g.,
human and machine). The reason why Takt Time needs to be measured in port operations
is because Takt time is more than a metric of time — it is a whole different approach to
thinking about running operations in the Lean environment. In the context of the Lean
system, Takt time describes the rate of customer demand in which the service and
product is being pulled by port customers.
The idea of using Lean approach is that a lot of the “waste” in traditional (port) processes
can be reduced or avoided by using it as the “drumbeat” of port operation. If every step
within the operation process produces to the drumbeat, there will be no overproduction
waste, and combined with a service “pull” system, a port will be able to deliver goods on
an even flow (no peaks or troughs) throughout the process. Then the port operators will
have the opportunity to reduce Work in Progress (WIP) and lead times, while maximizing efficiency.

First, Takt time ensures that all the capacity in a targeted business is planned and used and satisfies overall customer demand. Takt time will facilitate the delivery of the right product/service in the right quantity at the right time to the customer. The right product or service can still be achieved with right quantity and time without implementing Takt time measurement; however, this could lead to much waste (muda) of human and machine (Womack et al., 1990).

Second, Takt time creates a constant pace or pulse across port different processes, which will instantly highlight capacity issues, service quality issues, synchronization among port processes issues and many others. Understanding Takt Time enables the port operators to estimate their service delivery process and process outcome, and eliminate the waste of overproduction by providing services to actual customer demands. The Takt time helps to develop standardized work instructions, thus encouraging quality and efficiency and, more importantly, it helps the port operators to set real time targets for service delivery that show the port employees and management exactly where their output is.

The calculation for Takt time is as follows:

\[
\text{Takt time} = \frac{\text{Net Available production/service Time per day}}{\text{Customer Demand per day}} \quad \text{(Pereira, 2008)}.
\]

Where net available production/service time per day= total production/service time – break times – maintenance activities times – working shift changeover – working facilities clean down time.

And

Customer demand per day= amount/number of units required by customer/ time period.

In the port business, Takt time can be calculated on a per shift basis instead of on a per day basis as mentioned in the formula. Further, the units of customer demand are calculated according to the type of cargo handled measures (ex. TEU’s, Tons, car).
4.3.5. Steps of Calculating Takt Time

Accurately measuring Takt time and cycle time requires six steps that can help identifying areas for targeted port performance measurement as follow:

**Step1**- calculating net available time (excluding breaks, lunch/dinner times, planned maintenance and other non-value added activities). Available time is a fundamental Lean concept that is sometimes referred to as net available working time or available working time. Available time indicates the planned time during which port resources are available to meet customer requirements. It therefore forces a certain “tension” to sustain and initiate a perpetual improvement process. Improvement processes should be oriented to satisfy port customer’s requirements more effectively within the available time by identifying/eliminating waste, overburden and unevenness as manifested in actions such as insignificant interruptions, changeovers, and catastrophic stoppages.

A port operation might determine the net available time according to the availability of resources and planned stoppages, though if the unplanned breakdowns occur more frequently, it may aggressively address the unreliable operations from the customers’ point of view. Many factors may affect the net available time such as the weather conditions, equipment technical conditions, the conflict between the operations for multi-purpose port and national legislation on daily working hours. Therefore, calculating the net available time and highlighting its impact on the port productivity will force the authorities to adjust working time accordingly.

**Step2**- calculating the demand that the end user or customer typically requests every hour/day/week/month. For a port like Umm Qasr Port that is multifunctional and handles different types of cargos, the demand of port customers is diversified over container handling, RORO units, bulk cargo, break bulk cargo and general cargo. Therefore, the units of measurement differ from and average customer demands vary in relation to the type of shipping business. For the average Takt Time calculation to be satisfactory, it requires a stabilized demand environment. However, it is rare to maintain such an environment in reality for the port because maritime businesses experience variable demand over time, depending on several factors.

Normally, the demand for a service is measured according to the average value of previous data for the performance. For instance, when a process deals with ten cases of
service delivery that are delivered differently each time, as Lean practitioner, a question should be raised about the reasons for such variations and start correcting them. Lean approach differs from the traditional approach of measuring demand by taking the shortest time for delivering a service as the standard time for measurement. Therefore, this research measures customer demand depending on the previous performance data, using the optimum cargo handling rates. However, the research should discuss whether this demand satisfies the customers and adequate service level compared to similar ports.

In the case that the port is satisfying customer demand, delivering port service slower than Takt time causes bottlenecks within port operations and longer waiting time. On the other hand, faster service delivery than the Takt time produces another type of waste “overproduction”, which will lead to extra costs. Unsatisfied customer demand will result in longer Takt time, which requires more time for delivering a service and reducing the port productivity level even though the demand is accurately calculated. The consequences of long Takt time will lead to unhappy customers.

**Step3**- Calculating Takt time by using the formula (Available time/ Demand). Lean practitioners found that Takt time cannot be measured with a stopwatch. It can only be calculated, and the service delivery process needs to be set according to Takt time with a constant rate. The defined rate of demand offers more clear-cut tools for shipping lines calling the port to determine the time of vessel turnaround, both inside port and sailing time, to keep their fixed schedules.

**Step4**- Calculating the Cycle Time of port services that is defined as the time from when the Operation begins on demand to the time when the operation ends. In fact it is a Throughput measure (units per period of time), which is the correlative of Cycle Time. This relationship is similar to Takt Time (amount of time per unit), which is correlative to rate of customer demand (units per period of time). The Cycle time clock starts when work begins on request and ends when the item is available for handing over. Cycle time is a more mechanical measure, used for determining process capability.

Lead-time is the whole period of time required for delivering a product or a service starting when the customer orders it and ending at service delivery. In the key performance indicators (KPIs) for ports there are similar measures to cycle time and lead-time that are often called productive time and service time.
Figure 15 shows the similarities of measuring times of port operations by using the KPIs and Lean approach. The service time of discharging a vessel includes productive time used for discharging the entire cargo from the vessel to the storage yards and idle time of pre-discharging preparations. On the other hand, the cycle time of discharging the vessel’s cargo measures the value-added activities in the operation process, whereas the Lead-time covers the value-added and non-value-added period of time. However, the cycle time might have wastes within the operation process that need to be identified by the port’s Lean team and eliminated, in order to satisfy customer demand.

The example in Figure 15 explains the comparison between the time terminology used to express the port productivity measures between KPI measurement and Lean approach measurement. Many factors may affect the productivity of a port such as number of working shifts, shift working hours, size of working shifts, number of harbor/gantry cranes deployed and number of moves per hour per ship.
Shipping lines expect high port productivity in order to shorten the Lead-time of a vessel inside the port, which requires the port management to maintain process improvement through eliminating all unnecessary non-value-added activities.

The collected data from the Port of Umm Qasr indicates that there is a fluctuation in the number of moves per hour per ship of 37-61 container moves. The variation results from various reasons such as inconsistency of the number of deployed cranes and trucks, the working hours per shift, number of items of yard equipment deployed and distance between the berth and storage yards. With such variation, the shipping lines can hardly satisfy and meet their sailing plans since the productivity inconsistent.

Table 15: Takt time calculation for discharging container vessels in Umm Qasr Port

<table>
<thead>
<tr>
<th>Takt Time Calculator</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Working Gantry Cranes per Day</td>
<td>3 Crane</td>
</tr>
<tr>
<td>Hours per Gantry crane</td>
<td>12 Hours</td>
</tr>
<tr>
<td>Break Time per Shift/Crane (paid)</td>
<td>60 Minutes</td>
</tr>
<tr>
<td>Lunch Time per Shift/Crane (paid)</td>
<td>60 Minutes</td>
</tr>
<tr>
<td>Planned 5S time per Shift</td>
<td>Minutes</td>
</tr>
<tr>
<td>Planned Downtime per Shift</td>
<td>60 Minutes</td>
</tr>
<tr>
<td>Customer Demand per Day</td>
<td>800 move Loading/Unloading</td>
</tr>
<tr>
<td>Available Time per Shift</td>
<td>720 Minutes</td>
</tr>
<tr>
<td>Net Working Time per Shift</td>
<td>540 Minutes</td>
</tr>
<tr>
<td>Net Working Time per Shift</td>
<td>32,400 Seconds</td>
</tr>
<tr>
<td>Net Available Time per Day</td>
<td>97,200 Seconds</td>
</tr>
</tbody>
</table>

Implementing the formula for calculating Takt time on the container terminal ship to shore operation has indicated that 2.03 minutes is required to move a container from ship
to shore. The pace of terminal productivity is relatively slow considering that three gantry cranes are deployed to discharge the vessels with an average productivity of 10 moves per gantry crane per hour. The gantry cranes’ productivity might not be equal as the condition of the cranes and drivers’ skills normally vary. Therefore, it is recommended that these elements be leveled as much as possible to deliver a consistent service.

In order to run balanced port operations, the yard transport operation and storage operation should be operated with the same Takt time as the ship to shore operation (2.03 minutes per container). Operation planners have to provide a sufficient quantity of handling equipment and employees within the proper operation distances.

Table 16: Re-calculating Takt time with reduced Break time

<table>
<thead>
<tr>
<th>Takt Time Calculator</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Working Gantry Cranes per Day</strong></td>
</tr>
<tr>
<td><strong>Hours per Gantry crane</strong></td>
</tr>
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</tr>
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</tr>
<tr>
<td><strong>Planned 5S time per Shift</strong></td>
</tr>
<tr>
<td><strong>Planned Downtime per Shift</strong></td>
</tr>
<tr>
<td><strong>Customer Demand per Day</strong></td>
</tr>
<tr>
<td><strong>Available Time per Shift</strong></td>
</tr>
<tr>
<td><strong>Net Working Time per Shift</strong></td>
</tr>
<tr>
<td><strong>Net Working Time per Shift</strong></td>
</tr>
<tr>
<td><strong>Net Available Time per Day</strong></td>
</tr>
</tbody>
</table>

\[
\text{Takt Time} = \frac{720}{122} \approx 5.9 \text{ Seconds per move}
\]

More importantly, knowing operation Takt time gives operation team members a way to foresee exactly what “success” looks like for each and every unit of service from the
vessel to the storage facilities. For the variable demand, Takt time needs to be re-adjusted according to customer demand as it is known that shipping lines have different requirements. Comparing the net available time with the total working time for the cranes, as an example, indicates that 25% of the total time planned is non-value-added time, in addition to unexpected stoppage of cranes for different reasons. The wastage of time due to long breaks reduces productivity and increases the cost of non-value-added activities that customers are paying for.

The research suggests that port operators combine break time with lunchtime to be 60 minutes all together instead of separating the two breaks and stopping operations for 120 minutes. Moreover, the planned downtime per shift can be reduced to 30 minutes and includes the 5S time within this period, in order to minimize the wastage of time. Table 16 shows the result of testing those suggestions and re-calculating the Takt time by considering the same pace of operation (2.03 minutes per move), resulting in increasing the demand level. In other words, the terminal can handle 930 moves per day instead of 800 moves per day, which is 14% more capacity added by only reducing planned break times.

Berth Planning shall allow for planning all resources put into terminal operation, such as berth and gantry cranes. It shall assign berth locations for vessels making calls to the terminal. This process shall help planners to find optimum berthing positions, taking gantry crane coverage and maintenance schedule into consideration. Gantry Crane Planning shall assign numbers and types of quay cranes for vessel operation, and shall allow for an automatic long-term schedule creator that reduces efforts and time in vessel schedule registration work, using its regular schedule.

Similarly, the port operators can measure the Takt time for the break bulk cargo discharging process by using the same calculation techniques as shown in Table 16. The collected data from port management states that stevedores work in two shifts per day, and each shift works 8 hours, including planned breaks and unplanned stoppage. The shipping agents are paying port dues according to this time set, but if they want to increase productivity, a third shift might be asked to continue discharging against extra
payment to the stevedores. Increasing working hours creates high productivity and shortens vessel turnaround time, which will consequently improve port efficiency.

Table 17: Calculating Takt Time for Break Bulk discharging process

<table>
<thead>
<tr>
<th>Takt Time Calculator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working harbour Cranes per Day</td>
</tr>
<tr>
<td>Hours per Harbour crane</td>
</tr>
<tr>
<td>Break Time per Shift/Crane (paid)</td>
</tr>
<tr>
<td>Lunch Time per Shift/Crane (paid)</td>
</tr>
<tr>
<td>Planned 5S time per Shift</td>
</tr>
<tr>
<td>Planned Downtime per Shift</td>
</tr>
<tr>
<td>Customer Demand per Day</td>
</tr>
<tr>
<td>Available Time per Shift</td>
</tr>
<tr>
<td>Net Working Time per Shift</td>
</tr>
<tr>
<td>Net Working Time per Shift</td>
</tr>
<tr>
<td>Net Available Time per Day</td>
</tr>
</tbody>
</table>

Takt Time = 23 Seconds per ton

Takt Time = 0.39 Minutes per ton

Source: Authors, 2015.

The selected port as a case study mainly discharges cargo from vessels using direct operations through direct delivery of bulk and break bulk cargo. Therefore, the productivity of the port will be dominated by the availability of trucks and smooth
hinterland connection. The port is well connected to the national railway network that allows trains to be loaded from the vessels directly. The train flow within the port area is faced with several obstacles due to the absence of an effective communication system between the port authority and Railway control unit because both use a traditional bureaucratic system and port operation system (POS).

The current operation in the Port is characterized by operations and administrative procedures, where most data and information exchange is carried out on paper in offices at multiple locations inside the port operations area. This results in operational delays and in private individuals and vehicles entering the port operations area.

Trucks are currently allowed into the operations area before the cargo has been released (by Customs, Port, and Shipping lines). In addition, import cargo is subject to customs inspection inside the operations area after being loaded to trucks. This results in many trucks and persons (agents, customs officers, etc.) inside the operations area, causing safety and security risks as well as obstructing efficient cargo and equipment flow.

Such unbalanced operation creates difficulties in maintaining the same pace of operation (Takt time) that would result in variable service provision and an inconsistent pull system from the customer side. Considering the fact that bulk and break bulk business as tramp shipping is less concerned with time compared with liner shipping, a variation in Takt time with a safety factor may have to be acceptable. However, the important element in implementing industry standard operations and administrative practices is the provision of a standardized Port Operating System (POS) that will allow the Umm Qasr Port to achieve higher asset utilization, volume capacity, and efficiency.

Umm Qasr Port has a well laid out RO/RO ramp located at Berth 21, which adjoins the container terminal at the north end of the river. This ramp is well designed and able to support traffic moving to and from a RO/RO vessel. It is 40 meters long and 18 meters wide on the landside end. Implementing the same methodology to calculate the Takt time for RORO vessels as shown in Table 18 indicates that the productivity of this terminal is unsatisfactory due to the shorter working hours applied.
The terminal is operated with two shifts of 8 hours each and the breaks are two hours, so the actual number of working hours per day is 12. The research suggests 3 working shifts, extending the working hours to 12 hours, similar to container operations. By adding one more shift, the port can handle 1050 cars per day instead of 700 cars per day as performed currently. The distance between the berth and storage facility has an impact on the pace of operation as well as does the skill of drivers. Human resources functions, including payroll for all dockworkers as well as the office staff, will be a critical component of Lean implementation because this concept is all about changing working culture toward continuous improvement.
Figure 19 shows that the Takt time for container business at the port varies among the different processes due to several reasons related to batch size and layout. In order to synchronize the process to be leveled and harmonized, more trucks should be deployed to compensate for the longer time needed to transport containers from the ship to the storage yard. Otherwise, the pace of operations will be measured according to a Takt time of 2.9 minutes per move and not 2.03 minutes per move, which will result in unsatisfied customer demands.

Figure 19: The cycle time for discharging container vessel

Source: Authors, 2015.

Step 5: Draw a value stream mapping and there you can provide the Takt time at each activity step. A key principle in any business is creating value for customers, but how
much of the service provided by port operators in daily work lives actually creates value? We also need to know how much waste is actually created by port operations. The rationale behind Value Stream Management is to keep focusing on activities that add value within the process, looking for and eliminating the activities that do not. Value stream refers to all the steps, both value-added and non-value-added, required to take a product or service from raw materials to the hands of a customer. Mapping this value stream is a visual tool that enables the management to document all required steps from receiving the call for service to fulfilling customers’ needs and helping operators to observe what really happens in the service process. Value stream mapping provides an overall observation of the flow of information and materials or equipment across the entire process visible as a dynamic document (Pereira, 2014).

Figure 17: Cargo Handling Value Stream Mapping

Source: Authors, 2015.

Solutions to reduce port process waste can be identified during Lean events and in daily implementation of Lean principles and tools. The systematic identification and
elimination of non-value-added activity or “waste” involved in delivering port services to customers demonstrates that there are wastes within the operations that would be considered as difficulties for maintaining leveled Takt time. Previous research carried out by the author applied value stream mapping to the same port resulted in highlighting a number of non-value-added activities as an illustration of Lean implementation as shown in Figure 17 (Alfayyadh et al., 2015).

Implementing Lean techniques improves service flexibility (the ability to adjust to customer needs and alter or reconfigure service and processes in rapidly making the circumstances of the market changing) enabling a pull service implementation, oriented just-in-time system that minimizes capital requirements and inventory.

4.3.6. Benefits of Takt Time

The Takt time helps the operators to calculate working capacity through a complex flow by determining the capability of every process within the service delivery operation. Knowing the real capacity helps in distributing resources and controlling the speed of handling equipment operations according to the pace that satisfies customer demand. The layout of the working area has a significant impact on harmonizing operations within the calculated Takt time, especially when there are changeovers for cargo and shifts involved. The operations planners can monitor any process and quickly quantify the optimum number of workers required to get the assigned task done. Determining the Takt time provides the management with an opportunity to see the possibility of implementing Kaizen (continuous improvement) events. When Takt time is calculated and set as a goal for all working team members, they will easily measure their success and understand what success means for the customers as well as the port itself. Moreover, they will monitor every step in the process in order to maintain this time set, so they will immediately know what waste is preventing the process from being improved and know if something went wrong.

This research fills the gap in the literature in quantifying customer demand for the port of Umm Qasr and measuring the pace of processes for satisfying this demand. Takt is not a concept, rather it is a discipline and a measurement based on existing and known production/service practices and principles. Understanding Takt Time and Cycle Time is
the first actual step for Lean practitioners to move one step closer to improving the productivity and efficiency of their operations. The most important key point of calculating Takt time is to make it beneficial to all stakeholders, and real and applicable at the working yards; otherwise, it is only an abstract, theoretical research number.

The way in which Takt time synchronizing and leveling can create consistent satisfactory customer demand has been illustrated as an important factor of port performance. Therefore, it has a value from a port perspective in terms of strategic planning. It has also been found that the port time schedule for operations is not properly configured among the different operations and there is room for improvement in this regard.

The study has a few limitations; the selected port is performing data documentation mainly through paper work, which might not be 100% accurate. Further, the port data is not measuring KPIs, so it would be useful to compare the measured Takt time with KPIs. The Takt times of all processes for different port operations are not included in this paper due to the limitation of this research.

Calculating Takt time in this research recommends the port authority to make the Takt time for each process as much as equal in order to avoid bottlenecks between and within the port processes. Any differences in Takt time between processes means that more sources are used in the process that taking longer Takt time to move one unit of cargo.

4.4. Cost Benefits

According to Ohno (2007), there are three formulas to calculate the price of a product or service:

A. Price – Cost = Profit
B. Profit = Price – Cost
C. Price = Cost + Profit

Mathematically, the three formulas are the same. The first formula applies when the price of a service or product is already set so the service provider must reduce the cost to be able to compete with others on the same price point. The reduced cost of the service will be considered a generated profit for the service provider. The second formula is the trickiest one because the profit is moved to one side of the equation and the price and cost
are on the other side. The cost cannot be reduced in this formula instead the value added must be increased and luxury services provided in order to generate profit. In the third formula, a government or an authority may set the profit so that the service provider is expected to calculate the cost accurately.

The interpretation of the formulas by a port as a service provider will form the financial policy for the costs of service. Numerous companies choose to employ the Lean concept for three primary reasons: to reduce production or service resource costs and requirements; to increase customer responsiveness; and to improve product or service quality, all of which combine to boost company profits and competitiveness (EPA, 2013). Based on Umm Qasr port’s existing service pricing system, the third formula is applied because the port authority, which is a governmental body, decides the tariffs. In order for the port to reach high competitiveness, the first and second formulas need to be considered because the reduction of service cost and adding of value into port services will allow port customers to acquire more benefits.

The Port of Umm Qasr is a multi-functional port that handles different types of cargo, including containers. Therefore, the implementation of Lean concept can improve performance and productivity for all port operations and reduce costs. However, in this research the cost calculations of implementing Lean concept are applied on a container vessel with specific figures and facts in order to illustrate the impact of Lean implementation on service cost and profits that allow the port to reduce tariffs.

The marine dues are designed to include pilotage, berthing (harbor pilot, tug boats and mooring team), navigation aids services and dredging service to maintain sufficient water depth. The current vessel planning system creates a high utilization rate of work force and tugboats, resulting in frequent breakdowns and high operation cost. Similarly, the dredging strategy revision, implementing Smart Goals, enables the dredging department to preplan the dredging schedule, and allocate proper damping areas in order to prevent sediment returning into dredged locations, which will reduce operation costs as calculated in Table 19.

Implementing continuous improvement (Kaizen) in the cargo handling process combines the collective talents of an organization to create a vehicle for continuous waste elimination from the production processes. Additionally, the improvement of port
operation by applying a modern terminal operation system sustains the Terminal Handling Charges (THC) at an acceptable operation cost because it allows best equipment and labor utilization. Similarly, the lift-on/lift-off (LOLO) operation cost depends on the equipment and labor utilization rates. Therefore, any improvement in the management system generates a better usage of port resources and allows higher stacking of containers to reduce the cost of land required.

Finally, due to identified wastes within the port operation process, the cargo remains in the storage facility longer than clients’ expectations. Therefore, the required storage area exceeds the theoretical requirement that involves extra fixed and operation costs. The elimination of identified wastes will improve the storage operations and minimize the costs caused by these wastes.

Table 19: Cost Calculations for a Container Vessel

<table>
<thead>
<tr>
<th>Container Vessel Bill Calculations</th>
<th>Price /TEU</th>
<th>Fixed Cost</th>
<th>Operation Cost</th>
<th>Lean Operation Cost</th>
<th>Current Profit</th>
<th>Expected Lean Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Marine Dues</td>
<td>20</td>
<td>8</td>
<td>6</td>
<td>5.1</td>
<td>6</td>
<td>6.9</td>
</tr>
<tr>
<td>2 THC</td>
<td>82</td>
<td>32.8</td>
<td>24.6</td>
<td>19.68</td>
<td>24.6</td>
<td>29.52</td>
</tr>
<tr>
<td>3 LOLO</td>
<td>61.5</td>
<td>24.6</td>
<td>18.45</td>
<td>14.76</td>
<td>18.45</td>
<td>22.14</td>
</tr>
<tr>
<td>4 Stripping</td>
<td>99</td>
<td>39.6</td>
<td>29.7</td>
<td>20.79</td>
<td>29.7</td>
<td>38.61</td>
</tr>
<tr>
<td>5 Storage</td>
<td>4</td>
<td>1.6</td>
<td>1.2</td>
<td>1.08</td>
<td>1.2</td>
<td>1.32</td>
</tr>
<tr>
<td>6 State Agency fee</td>
<td>6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.3</td>
<td>4.8</td>
<td>5.1</td>
</tr>
<tr>
<td>7 Private agency fee</td>
<td>2</td>
<td>0.8</td>
<td>0.6</td>
<td>0.36</td>
<td>0.6</td>
<td>0.84</td>
</tr>
<tr>
<td>8 Total</td>
<td>274.5</td>
<td>108</td>
<td>81.15</td>
<td>62.07</td>
<td>85.35</td>
<td>104.43</td>
</tr>
</tbody>
</table>

Assumptions:
1 Container vessel GRT/ 24724 3 10 days free storage
2 No. of full Containers 788 TEUs 4 No addition moves

Source: Authors, Port Tariff and Port Technical Department Report, 2015

In order to reduce the cost of breakdowns and high operation cost, Total Productive Maintenance (TPM), a holistic method of maintenance, emphasizes preventative and
proactive maintenance to maximize equipment operational time.

TPM obscures the distinction between production and maintenance by putting a strong focus on empowering equipment operators to maintain their equipment.

The Umm Qasr Port authority outsourced cargo-handling activities to a pool of local stevedoring companies as well as the global port operators. Shipping lines and shipping agencies revealed that many local stevedoring companies lack qualified workers, which results in cargo damage and reduced productivity. Moreover, they emphasized the low level of effectiveness of cargo handling equipment due to continue breakdowns during the unloading process.

Table 20: OEE calculation for a shore crane

<table>
<thead>
<tr>
<th>Production Data</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift Length</td>
<td>720 Minutes</td>
</tr>
<tr>
<td>Short Breaks</td>
<td>15 Minutes Each</td>
</tr>
<tr>
<td>Meal Break</td>
<td>120 Minutes Total</td>
</tr>
<tr>
<td>Down Time</td>
<td>50 Minutes</td>
</tr>
<tr>
<td>Ideal Run Rate</td>
<td>2.4 TPM (Ton Per Minute)</td>
</tr>
<tr>
<td>Total Unloaded cargo</td>
<td>600 Tons</td>
</tr>
<tr>
<td>Damaged Cargo- Tons</td>
<td>7 Tons</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Support Variable</th>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned Production Time</td>
<td>Shift Length - Breaks</td>
<td>585 Minutes</td>
</tr>
<tr>
<td>Operating Time</td>
<td>Planned Production Time - Down Time</td>
<td>535 Minutes</td>
</tr>
<tr>
<td>Good cargo</td>
<td>Total cargo - Damaged</td>
<td>593 Tons</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OEE Factor</th>
<th>Calculation</th>
<th>My OEE%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>Operating Time / Planned Production Time</td>
<td>91.45%</td>
</tr>
<tr>
<td>Performance</td>
<td>(Total cargo / Operation Time) / Ideal Run Rate</td>
<td>46.73%</td>
</tr>
<tr>
<td>Quality</td>
<td>Good cargo / Total cargo</td>
<td>98.83%</td>
</tr>
<tr>
<td>Overall OEE</td>
<td>Availability x Performance x Quality</td>
<td>42.24%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OEE Factor</th>
<th>World Class</th>
<th>My OEE%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>90.00%</td>
<td>91.45%</td>
</tr>
<tr>
<td>Performance</td>
<td>95.00%</td>
<td>46.73%</td>
</tr>
<tr>
<td>Quality</td>
<td>99.90%</td>
<td>98.83%</td>
</tr>
<tr>
<td>Overall OEE</td>
<td>85.00%</td>
<td>42.24%</td>
</tr>
</tbody>
</table>

In order to examine the conditions of cargo handling equipment, an experiment was conducted to determine the Overall Equipment Effectiveness (OEE), which consists of
three components. Performance of equipment is the comparison between the actual outputs with what the particular equipment should theoretically produce. While the availability of equipment is how much time is available to utilize the equipment compared to how much time the equipment could be run in reality. A third component is the quality of equipment and the conditions of produced service if there are damaged or rejected quality. Table 20 shows OEE calculations for a harbor crane used for unloading packed rice from a vessel into trucks. It illustrates that the OEE is very low, especially the performance component compared with world class OEE. Therefore, the Total Productive Maintenance (TPM) as part of Lean tools needs to be used to maintain the equipment in good condition.

Figure 18: Total Productive Maintenance (TPM) Elements

Implementing TPM helps not only in maintaining the effectiveness of cargo handling
equipment but also in eliminating environmental pollutants. For example, carrying out the 5S exercise (Sort, Set in Order, Shine, Standardize, and Sustain) ensures a well-organized and clean work environment by eliminating anything that is not needed, and sustains this working condition continuously. On the other hand, maintaining cargo handling equipment reduces the level of emissions generated and reduces energy consumption because engine efficiency is increased.

4.5. Service Quality
Several ports worldwide are unable to offer potential customers the right standard or mix of port services as a consequence of the lack of right infrastructure combination. Subsequently, frequent complaints from port users relate to:

- Insufficient water depth.
- Insufficient quay space and high occupancy ratio, causing ships to have to wait for a berth.
- Insufficient storage spaces adjacent to the berth, normally seen at older ports, which are located near the city center.
- Outdated cargo handling equipment.

In container terminals and for container vessels, customers’ most common complaints relate to the number of gantry cranes impeding the container vessel from unloading as many cargo hatches as the terminal operator would prefer, resulting in slower container handling rates. In addition, storage yard congestion results from a lack of storage space, which also slows down yard throughput and crane handling rates at the container terminal.

For bulk terminal customers, the most common concern is poor unloading capacity and lack of equipment automation such as pneumatic and ship loaders or screw unloading equipment connected to efficient conveyor systems to the storage silos. Another common complaint concerns improper linkage arrangements with inland waterway and rail transport.
The rapid growth in vessel size was the main reason for infrastructure problems and the consequent need for big investment in ports. There are other reasons for lack of investment such as contractual legal certainty for investors, port institutional arrangements and the possibility of recouping the costs of investments by ports (PwC & Panteia, 2013).

Other main factors affecting the quality of service delivery by a port are mostly organizational and focus on:

• Service Availability: the range of provided services within the port facilities;
• Speed of service delivery: time needed to handle cargo and ships;
• Operation Reliability: port performance consistency; and
• Flexibility of operation processes: capability of providing alternative methods if something goes wrong.

1. Normally, service availability has two sides: firstly the ability of the customer to specify the services of ship and cargo handling that would be provided by the port operation, and secondly the port ability to facilitate or provide value-added activities.

Most port customers prefer to have more control of the services of the port, including:

• Priority of reserving vessel-berthing windows in order to assure that unexpected waiting for a berth would not disrupt the vessel’s scheduled terminal services;
• The customer’s ability to discuss and negotiate service providing contracts with the cargo handling company or port authority in order for them to offer a guaranteed ship turn-around time or loading/unloading rate;
• Provision of dedicated storage yards within the port area; and
• Extended delivery times and cargo collection.

There are relatively small ports that may not be able to allow their customers such level of control without adding a significant cost to the service price and/or undue disruption to other port operations offered to other customers. On the other hand, other ports are considered large enough to create fair competition among terminal operators to handle this issue. Hence, the medium sized ports that are dominated by local monopolies, either
by the public or private sector, are strong enough to ignore these types of requests, even if they are financially and physically practicable.

As a result, outsourcing of logistics management in recent years has increased value-added services substantially and the use of improved processes has contributed significantly to supply chain efficiency. However, many port authorities are reluctant to satisfy the need for such value-added activities themselves or even to facilitate the involvement of the private sector to provide such services, whereby the port authority would be seamlessly interconnected with mainstream port operations. The Main reasons for such reluctance are:

• Applicable Legislation on specific port function.
• Perceptions of management and politics are narrow in relevance to the port’s role;
• Lack of space for extensions, lack of funding for investment or inexperience of port management;
• Avoidance of unknown risk; and
• Passiveness, resistance to change or lack of vision.

Implementing Lean approach for port operation processes improvement may address such problems for both traditional and non-traditional port services because both private and public sectors would be able to implement this approach when the tools are used successfully. Partly because of the advantage of Lean, however, it has been important to determine these problem drivers further in this research in order to evaluate their relevance and importance.

2. In respect of ships, port service speed is reasonably well studied and measured because VTT is a common port PPI. Speed of service is an area where the possible comparison of port performance should be across a wide spectrum of ports. On the other hand, service speed for cargo, usually defined as cargo dwell times, is more difficult to measure and even harder to comprehensibly explain. Many ports record this type of data in respect to containers: however, port authorities rarely officially publish this information. A very limited number of ports save similar information records for general cargo and bulks in
part due to the diversity in the composition of commodities and the involvement of a large number of consignees/shippers, which makes cargo data aggregation harder.

Longer storage periods or cargo dwell times result from many causes. These causes are challenging to overcome and often lie outside the control of the terminal operator or port authority. Cargo documentation errors, slow procedures of cargo clearance, the advantage for customers to use the port as free or cheap warehousing, and uncertainty regarding inland destinations of cargo at the time of discharge are some examples.

3. Port service reliability is seemingly more essential with the shift toward Lean production theory and inventory minimization. Many ports are unable to provide reliable services due to a number of reasons:

- Service demand peaking and variability;
- Shortages of capacity due to insufficient investment; and
- Poor operations integration including labor deployment.

Although the demand peaking is mostly outside the control of the port authority, a proper plan can do more to handle increasing cargo and maintain service reliability. This can be achieved by a scientific analysis of the patterns of past demand, efficient networking with customers, IT systems integration, obtaining best real-time data on imminent vessel arrivals/departures, and providing greater reserve capacity margins.

Provision of additional spare storage capacity is a controversial matter, as it requires more investment, but customers might not be prepared to pay for it. Similar to other service providing industries, ports experience broad changes in the preferred proportion of price/reliability. Although the port customers’ preference is to see reliability with higher standards at each step of the operation process, this reliability does not come cost-free. Practically speaking, the current diversity in standards may improve the effectiveness of the supply chain by providing opportunities for single ports to identify and exploit variances customer preference. This statement is only applicable where an adequate level of port competition exists. However, if customers are unable to decide their preferred balance between cost and reliability in such monopoly situations, high ranges of unreliability are presumed to continue uncorrected.
Improved operational management is connected to a great extent to the issue of flexibility of service provision but also pinpoints the approach how port managers would define the provision services. Often obligations of port service are only presented in physical terms with no timeline for service completion or other service quality indicator clearly attached. In addition, the port KPIs emphasize average port performance rather than port performance spread, which is considered to be one of the reasons why so little value is placed on reliability.

The best practice of Lean implementation and process improvement by waste elimination contribute to maximize the capacity of the port and vessel traffic by optimizing the use of all port resources and, thereby, reducing delays in preparing, searching and dispatching documents. The management of the port needs to share vessel information from all port sources by linking the operation processes in order to maintain a smooth cargo flow. The information shared has to include port, vessel, cargo information, and marine services. In addition, the port operation system needs to provide a one-stop service for the whole of the port community. The port service is required to assist users in identifying and quickly determining which vessel and/or cargo is to be inspected. To this end, accumulated data of all inspection results should be used as a decision supporting tool because this is a serious issue for vessels calling Umm Qasr Port. Building a comprehensive information management system integrated to sea-inland logistics would establish a world-class electronic infrastructure, making the port a logistics data hub for all port communities.

The implementation of Lean tools for port operations benefits each party expecting a higher level of service quality with regard to the following;

1. Government
   - Build information network connecting sea-inland logistics system.
   - Make and execute systematic policy through statistical analysis.
   - Make knowledge based decisions by leveraging operation processes.

2. Marine Port and Terminal Operators
   - Obtain information in time electronic data interchange.
• Minimize the time of preliminary arrangements.
• Shorten turnaround time by reducing vessel waiting time in port.
• Increase port and terminal productivity by utilizing pre-notification, cargo pre-arrival and pre-departure information.

3. Private Sectors
• Access to port logistic systems for information sharing and data exchange.
• Maximize data accuracy in operation and minimize re-handling or duplicating data entry.
• Reduce time and effort to obtain necessary information.
• Reduce non-value added activities within port processes.
• Major shift from service-push to service-pull aspects.
• Cost reduction by eliminating unnecessary waste.

4. Inland Transportation Companies
• Invest small total cost of ownership in system implementation and maintenance.
• Accelerate work process and broaden range of value added services.
• Increase competitiveness by sharing information.

In chapter five, the impact of Lean implementation on working time efficiency, energy consumption cost and CO2 emission will be calculated based on the suggested value stream map.
5. Chapter Five: How Lean Improves the Environmental Performance and Energy Management for Umm Qasr Port

5.1. Background

As a crucial node in transport networks, seaports undertake a significant role in promoting regional and economic development and international trade. Meanwhile, a large amount of capital has been invested in port infrastructure construction, reconstruction and maintenance due to the rapid development of ports. Thus, more attention needs to be paid for environmental protection while facilitating the development of port logistics in the coming decades. A port is not a direct site for production processing, nor does it have a large amount of material consumption; however, it is an important distribution center for various goods, allowing a large number of vehicles and ships to be engaged in transport operations, which can be a source of contamination (discharge of waste gas and rubbish) (Chen, 2009). Apart from these traffic conveyances, there is pollution from goods themselves such as coal dust, dangerous materials, and chemicals.

A study by the Iraqi Ministry of Health and Environment showed that in 2014, emissions of carbon dioxide (CO2), nitrogen dioxide (NO2) and dust from harbor districts throughout the country reached 47 thousand tons, 61 thousand tons, and 349 thousand tons, respectively, significantly contributing to environmental deterioration in Iraq. Pollution from the port operation will not only damage the ecological balance of nature and the urban environment but also cause adverse effects on global climate change, which further increases the risk associated with port operations. The development of a low-carbon economy is considered to be a fundamental way to solve environmental problems. Nevertheless, ports and shipping still lack effective control measures for emissions of GHG gasses, and the importance of sustainable development is still being ignored by many port authorities (Wang, 2014). In view of this, the concept of green port (or low-carbon port) was proposed at the United Nations Climate Change conference in 2009 (Wu and Ji, 2013). On the basis of the organic combination of port development, utilization of resources and environmental protection, green port refers to a port characterized by a healthy ecological environment, low pollution, reasonable utilization of port resources, and low energy consumption (Chen, 2009).
In the US, Japan, and many developed countries, prominent achievements have been obtained by actively exploring and implementing the planning and construction of green ports (Gupta et al., 2005; Cai, 2010). As one of the advocates of green port, the Port of Long Beach has made remarkable achievements. The “green port” policy was launched in the Port of Long Beach in January 2005 with a series of environmental protection plans developed from seven aspects, namely water quality protection, improvement of air quality, soil conservation, wildlife and habitat protection, alleviating traffic pressure, sustainable development and community participation (Lv, 2005).

Since the implementation of the above environmental protection plans, the water quality of Long Beach has improved. In the meantime, Sydney Harbor carried out the Green Port Guidelines from other aspects, paying more attention to water and air quality, biological diversity, noise control, rubbish and dangerous cargo management, and environmental education and training (Lu and Hu, 2009). Strengthening legislation and enforcement is the main aspect that Sydney Harbor focused on. In Italy, shore power supply systems were equipped in both the Venetian Harbor and Port of La Spezia in 2010, resulting in a 30% reduction of the CO2 emissions, 95% reduction of the nitric oxide (NO) emissions, as well as significant noise reduction (Cai, 2010). In Tokyo Harbor, when planning the layout of the port, its influence on the environment was considered in terms of both ecological and living environment. It was also required that the port construction project and environmental protection planning should be implemented simultaneously (Liu, 2004).

The aforementioned countries apply “green” to their port operations and design of port construction to strengthen the port infrastructure and emergency response capability. Container terminals not only include various types of transport vehicles and logistics activities but also various activities of supply chain and industry. All container terminal activities are capable of creating exhaust emissions, including such pollutants as CO2, CH4, N2O, NOx, SO2, PM, DPM, and VOCs. Since terminal operators and shipping companies must maintain safety and sailing schedule accuracy to reduce operating costs and strengthen competitiveness, the efficient and effective use of container handling equipment is key to container terminal operating performance. Eide et al. (2011) found that most GHG emissions are created by cargo handling equipment in container terminal
operations. Container terminal operations emit 36% of CO2, 31% of PM, and 22% of NOx emissions. In addition, roughly 3% of total PM emissions are generated by tugboats and locomotives, while roughly 1% is accounted for by terminal tractors.

An investigation of the academic literature on green container terminals highlights that, while there is substantial research related to container terminals, there are few papers from a carbon footprint perspective on green container terminals. Clear definitions of green container terminals have been provided by Sisson (2006). While Clarke (2006) found that employing automation for container handling equipment defines green container terminals; however, a lack of quantitative analysis is noticed in their research. The elements of green management practices have been investigated by Lun (2011) as well as their association with container terminal operating performance. Geerlings and Dubin (2011) applied a likely method to measure the CO2 emissions of green container terminals, and suggested numerous countermeasures to reduce them. In addition, the ranking order of container handling equipment in terms of carbon dioxide mitigation performance was determined by Yang and Lin (2013).

Liao et al. (2010), the Herbert Engineering Corporation (2011), and Mckinnon (2009) introduced calculation formulas for carbon dioxide emissions for different types of handling equipment. Assessing the overall green port performance of container handling equipment from the perspective of carbon footprint will not only permit the evaluation of carbon dioxide emissions and energy savings of different types of equipment, but also assist in facilitating solutions able to achieve green port targets (Yang and Shen, 2013).

In order to determine the ranking order of the two scenarios of operating models, gray relational analysis was applied in this research. In 1982, Julong Deng extended his gray theory to introduce the Gray relational analysis (GRA). In order to take the right decision to solve multiple concept problems, the GRA has been demonstrated to be an accurate and easy to use method (Tsai, et al., 2003). The GRA provides acceptable results with little data required and is simple to use, which was sufficient reason to use this method to measure Lean impact on port operations (Liu et al., 2008). Lau and Zhao (2008) stated that Deployment of Effective cargo handling equipment is a crucial factor in improving the overall performance and efficiency of cargo handling in export, import and transshipment operations. While Geerlings and Duin (2010) studied operations in the port
of Rotterdam to demonstrate the optimal layout of a container terminal for reducing carbon dioxide emissions by approximately 70% reduction of CO$_2$. Sisson (2006) proposed that a green terminal feature include automated transport vehicles such as AGV (automated guided vehicle) with low emission technology, cold ironing for ships, and electric yard cranes.

On the other hand, Pedrick (2006) proposed that better materials and systems, lower water usage, beneficial site planning, improved environmental quality and greater energy efficiency could be included in green terminal features. Pedrick (2006) argued that the design of green terminals should be harmonized with their sites, enhance the overall infrastructure, promote high efficiency, provide links to the community and improve economic aspects. It has also been suggested by Sisson (2006) that the green terminal functions at berth should comprise electric service for vessels, reduced vessel idling by automated mooring, electric shore cranes, automated terminal tractors with low emission, and automated RTG, and should take into consideration that the engines of external trucks should be turned off during idle time.

Clarke (2006) explained how the green container terminal requirements could be met by automatic equipment, which produces lower climate impact, lower GHG emissions, reduction of container damage, control of pollutant emissions, less energy consumption, improved operating efficiency and mitigation of noise pollution. Lazic (2006) suggested electric Rail Transtainers (RT) capable of ensuring improved air quality, low environmental impact, no exhaust emissions, high efficiency, no noise pollution and low lighting energy requirements. Choi et al. (2011) evaluated the conversion of Tire Transtainers to Electric Tire Transtainers with a cable reel system at Pusan port and reported that a 10% reduction in energy consumption resulted from this change. The same study claimed that CO$_2$ emissions could be reducing by 35% if the port uses hybrid energy operation tractors. Further, if the improvement options are adopted together with technical solutions for reducing the idling time of tractors, CO$_2$ emissions can be reduced by 16.7%. Geerlings and Duin (2010) suggested numerous measures for CO$_2$ reduction in container terminals including the employment of technological means for reducing the impact of specific patterns of behavior such as use of hybrid vehicles, modern vehicle design and increasing efficiency through technical engine improvements. They further
suggested applying conversion processes to lessen the harm of behavioral styles or modes of transport such as using improved driving models or alternative energy, and, moreover, allowing a reduction in overall transport volume by means of organizational measures and optimal configuration.

The above mentioned studies recommended the usage of technology, modifying the port layout and investing in new green projects in order to reduce CO₂. Absent from the literature are studies on the elimination of environmental waste within the operation processes of ports. Therefore, this paper aims to establish a model for the comprehensive assessment of green port development and proposes supporting methods for realizing quantitative evaluation by implementing Lean approach, which improves the operation process and reduces harm to the environment without heavy investment. The significance of undertaking this study is that the Environmental, Health and Safety (EHS) personnel in every organization should have information and ideas concerning preferable environmentally friendly processes, materials and equipment.

In contrast, no such knowledge or personnel exist in the selected port, which results in a lack of concern for environmental waste and its systematic elimination.

A careful literature review reveals that problems associated with green port development, particularly in such developing countries as Iraq, mainly include:

a) The port of Umm Qasr is an old port that came into service a few decades ago. Generally, this port lacks support from government funding and operates under management with outdated concepts and techniques.

b) Little consciousness of environmental protection and energy saving, which results in lack of systematic and comprehensive planning and design when developing green ports.

c) The lack of sound evaluation criteria for development of a green port that causes certain blindness in green port development and seriously affects the sustainable development of port resources, environment, and economy.

5.2. Environmental Wastes and Seven Deadly Wastes

As a result, there is a significant research gap to be filled, and a novel green port evaluation framework to be created. This was a strong point encouraging the researcher to establish a novel model for the comprehensive assessment of green port development
and propose supporting methods for realizing quantitative evaluation. Before measuring environmental wastes, it is significant to define them and understand the reasons for identifying them in the process. According to the United States Environmental Protection Agency, Environmental waste can be defined as the use of any unnecessary resources or released substances into land, air, and water that cause harm to human health or to the environment.

Environmental waste does not add value to port clients and these wastes can have a negative impact on service providing quality, flow, cost and time. The impact of environmental waste can be significant to identify as it creates costs associated with wasted energy, raw materials, and water. Environmental waste can either be easily seen as there would be a visual indication on containers of solid waste and hazardous waste or more difficult to see such as gasses and chemicals that have a negative influence on human health and the environment. Since ports use multiple resources and facilities to provide services, environmental wastes can be seen in almost any port process. It is important for the port to identify the process wastes in order to be able to quantify them when possible and measure their impact. The measurement of environmental wastes can pinpoint wastes that are the most important and influential to track over time.

For instance, it may be that CO2 generated by cargo handling equipment in one process is most important to measure, while dust waste is most important to measure for another process. From the customers’ perspective, most are not prepared to buy environmental wastes, waste risks, and their impacts. Ports that can deliver services with minimum environmental wastes impact have the potential to attract substantial competitive advantages as there will be lower costs, better service quality and shorter time. On the other hand, when ports implement Lean concept to eliminate environmental wastes, the working environment will be improved, offering better working circumstances for employees. Eliminating environmental hazards, similar to ergonomics concerns, can minimize potential exposure of employees to toxic substances and provide a safer and cleaner workplace. Subsequently, a high level of organizational morale toward the community will be reached, as the workers will take pride in their work because they think it has wider benefits to the world as well as their community. In order to explain the
impact of eliminating environmental wastes and how they are reflected in Lean seven deadly wastes, the table below shows the environmental impacts of each type of Lean wastes elimination. Value stream mapping (VSM) tools and techniques can be useful tools to help port authorities see environmental wastes in processes and identify and eliminate environmental wastes during kaizen improvement events.

The SERVQUAL test and port data reveals that the port has neither an environmental management system nor an Environmental, Health and Safety authority in place to monitor and control the environmental process. Chemical use and hazardous waste generation may be important to measure for one process, while water use may be most important to measure for another process. Environmental impacts that are associated with the seven deadly wastes targeted by Lean methods are listed in Table 21.

Table 21: Impacts of 7 deadly wastes on Environment

<table>
<thead>
<tr>
<th>7 deadly wastes</th>
<th>Impacts on Environment</th>
</tr>
</thead>
</table>
| Transportation and Motion | • Use more energy  
|                         | • Generate more emissions  
|                         | • Possible spills and damage during transport  
|                         | • More space required for Work In Process movement  
|                         | • Increased heating, cooling and lighting requirements                                       |
| Defect                | • Energy consumed in making defective service  
|                       | • Defective service requires re-do  
|                       | • More space needed for repair; use more energy for lighting, heating, and cooling.        |
| Over-processing       | • More equipment used  
|                       | • Increased wastes, energy use and emission of GHGs for unnecessary processing.             |
|                       | • More energy required  
<p>|                       | • More emissions                                                                                  |</p>
<table>
<thead>
<tr>
<th>Waiting</th>
<th>- Idle time causes wasted energy for lighting heating and cooling.</th>
</tr>
</thead>
</table>
| Overproduction | - More energy consumed in delivering unnecessary services.  
                  - Extra handling equipment used, resulting in extra waste disposal,  
                    more emissions and worker exposure. |
| Inventory | - More inventory space required which needs lighting, heating, and cooling  
                  - More energy required  
                  - Waste from damage or deterioration to stored Work In Process.  
                  - More disposal for expired parts |

In spite of this relationship between the environmental wastes and Lean seven deadly wastes, ports can improve their Lean performance by identifying environmental wastes during Lean activities. Port activities can create a number of wastes such as air emissions, solid waste, hazardous waste, energy use, water use, materials use and contaminated water. The existing environmental protection practices of the selected port were reviewed to map the environment value stream taking into consideration a number of elements as shown in Figure 19.

Obviously, there are more elements to be considered than those mentioned when examining a port environmental system but the limitation of data availability led to identifying only eight elements. The VSM for environmental process in Umm Qasr Port identified the most significant waste generating environmental problems for different stakeholders. Further studies can be carried out to map the current and future value stream by identifying and eliminating waste that would be defined during port operation process improvement. Therefore, due to the availability of data from the selected port, the focus will be mainly on measuring CO2 emissions and energy use by using carbon footprint analysis.
5.3. Energy Management

Lean Energy Management provides a service delivery process with an immediate and reliable method of observing how much energy is being consumed by cargo handling equipment, offices, and cars. Consuming more energy than needed generates
environmental waste that has significant impacts on human health as well as increases the associated costs to be paid by the port and its customers. There are several justifications for integrating Lean with energy management efficiency such as greenhouse gas management, cost savings, competitive advantage and environmental risk management.

Figure 20: Port Energy Management

In order to determine the impact of modifying port process and eliminating waste, an attempt to draw a graphical flowchart of port energy management consists of the most impacting factors on energy management, which can be seen, in Figure 20. There are two ways of identifying wastes that affect the efficiency of energy management. The first is
by mapping the whole value stream for the entire port operations similar to this research. The second way is to map the value stream only for the energy management process in order to identify the wastes and plan how to eliminate them, which will require further study.

5.4. Carbon Footprint Analysis

The main goal is to use carbon footprint analysis and gray relational analysis to measure CO₂ emissions produced by two different operation scenarios (Before Implementing Lean BL and After Implementing Lean AL) of four different cargo handling functions, namely container handling, RORO, dry bulk handling and general cargo handling in the port of Umm Qasr. The goal subsequent goal is to identify strategies for energy saving and CO₂ reduction for the terminal operator in compliance with the requirements of a green port. It has been confirmed that delivering quality port services by improving operation processes has a significant positive impact on environment protection and energy management. This positive impact needs to be quantified to illustrate how implementing Lean approach contributes to reducing CO₂ emissions and managing energy more efficiently.

The main objectives of carrying out these empirical analyses are to:

1. Measure the Carbon Footprint of the port and study green and Lean concepts.
2. Calculate the CO₂ emissions of various cargo handling models and types depending on an approach of carbon footprint;
3. Measure the ranking order in terms of CO₂ emissions of various cargo handling models for different scenarios by using gray relational analysis;
4. Compare the working time efficiency, CO₂ emission, and energy consumption cost before and after introducing Lean approach to port operations.
Figure 21 summarizes the carbon footprint analysis applied to two scenarios based on existing operations performance before and after eliminating process waste as proposed in the future VSM.
5.4.1. Methodology

The methodology in this chapter involves two stages of calculation by applying CFA and GRA. To find the amount of the CO$_2$ emissions per unit of cargo, Carbon footprint analysis is employed on four different operating models for various operation areas such as the ship to shore operation (ST), Quay Transfer operation (QT), Yard operation (YO) and Gate operation (GO) as shown in Figure 22. In this chapter GRA used to examine the ranking order of various cargo handling operating models taking CO$_2$ emissions, working time efficiency, and energy consumption cost as assessment criteria. In the first stage, CFA is applied to quantify CO$_2$ emissions per container for the container terminal based
on existing VSM. The second stage is to compare the results with the outcome of implementing future VSM. Similarly, the carbon footprint analysis is employed to calculate CO₂ emissions per ton of dry bulk cargo, per ton of general cargo and per piece of equipment handled from RORO vessels.

5.4.2. Port Operations

Before carrying out the measurement of working time efficiency, CO₂ emission and energy consumption, the cargo flow within the port will be divided into its three elements: (1) the cargo import flow, where it arrives by sea and leaves the port by road/rail; (2) the cargo export flow, where it arrives by road/rail and leaves the port by sea; and (3) a transshipment flow, where cargo arrives and departs by sea.

Figure 23: The port logistic systems

If these flows are streamlined from the perspective of port logistics, they can be seen in Figure 23. In order to perform the operations of the three flows, port operations are divided into three working areas, each of which has its own system and specialized handling equipment, and is linked to the others by a transfer cycle. These areas are the quay area or marine side interface, the storage yard or stacking yard area and the in/out gates or landside interface area (Moon, 2015).

The quayside operation focuses mainly on unloading/loading cargo from/to ships. The operation depends on the terminal size, the size of the marine side where ships are berthed and whether the terminal is made up of one or several quays. Accordingly, the number of gantry cranes or quay cranes employed to carry out the operation varies depending on the size of vessels and the handled volume. In order to transport cargo from the quay area to the stacking area, a number of prime movers serve the quay cranes, such as terminal tractors (TT), reach stackers (RS), straddle carriers (SC), automated guided vehicles AGV, Mafi trailers and forklifts. In addition to this equipment, the marine side interface area is supported by a marshaling area for container terminals where the operators place containers while they are waiting for the container handling equipment if they are instantly available. This marshaling area increases gantry crane productivity and reduces total container loading time.

The storage or stacking yard area is the second stage of cargo operation where cargo or containers are stored/stacked, waiting to be transferred to the next stage of the transport chain. In order to carry out these operation activities, the storage yard area is equipped with specialized handling equipment such as transtainers, inter alia tractor–trailer units, RS, SC, forklift trucks, mobile lift frames, and AGV. The selection of right equipment for cargo handling improves the operation efficiency and proper utilization of port resources. On the other hand, the dwell time of containers in the storage yard greatly complicates the process of terminal planning and affects the capacity of the terminal. Many factors may increase the dwell time for cargo or containers such as lack of handling equipment, type of handling equipment, stacking height, customs inspection procedures, accessibility to hinterland connection, the efficiency of operation, information flow and process efficiency.
To overcome the dwell time problem that results from limited yard space, the terminal can use rubber-tyred gantry cranes (RTG) or rail mounted gantry cranes (RMG) as the chosen options. Despite the fact that the selection of right equipment improves the operations, if the equipment is not efficiently operated, its productivity will be low. Many parameters influence the decisions of terminal planners in terms of where a container is to be placed in the stacking yard.

The third area is the landside interface where terminal operations are connected to other transport modes. Depending on the initial design of the terminal infrastructure, cargo can either be dispatched or arrive by road or by rail. It is through this interface that cargo and its detailed information arrives at the terminal, and the way in which it is managed will influence its performance. Accurate data helps to process the operation efficiently and to locate the cargo within the storage yard area. The connection with landside is divided into three sections, namely the input gates to the terminal, the output gates and input/output gates that can be changed depending on the level of traffic. The existence of input and output gates in the same terminal very much favor the Lean ports concept and a network of Lean ports as they serve the continuous flow of cargo through ports.

Basically, the transfer cycle includes the transfer of cargo from berth (quay side) to storage yard to be stored/stacked or to a yard where the cargo is placed to be dispatched and vice versa. It also concerns the movement of cargo from the storage yard to the gate and vice versa. Normally, the first transfer cycle implies using a prime mover to perform cargo transfer while the second cycle is performed by the transport mode that collects and/or delivers the cargo directly from/to the storage yard. According to the type of equipment and depending on the operations, straddle carriers or yard tractors, AGV and front loaders are employed in this operation. Moreover, the type of transport system employed has a direct relation to how the stacking has been executed, the layout of the yard, and operations of the terminal.

For the inbound flow of containers in Umm Qasr Port, the container terminal performs four activities to be considered as inbound containers:

1. The movement of a container from a container vessel by quay cranes or gantry crane to a prime mover or to the quay marshaling area
2. The movement of a container from the quay side or marshaling area by a prime mover to a buffer area in the stack yard
the pick-up of the container by reach stacker from the buffer area to its position within
the yard (4) the delivery of the container from its location in the stacking yard to the
ongoing transport mode, whether a truck or a rail wagon. Vessel arrivals vary at different
times and, in the absence of a proper schedule for berth allocation, the vessels need to
queue for berthing. Likewise, vessels calling the port vary in size, which implies that
several routs are being served by the terminal, some of which are regional and coastal,
while others are deep-sea. Every vessel has an expected duration of berthing and the stay
of a vessel in port is a complex function of several parameters.

Upon arrival of a vessel, it is moored in an allocated berth where cargo handling
operations are performed. To berth or to moor a vessel is to place the vessel alongside the
jetty line of a quay. If it is enough to be divided into different sections and hence an
attention need to be drawn to the distance of intership clearance. Therefore, it is proposed
that when numerous vessels are berthing, a berthing plan consisting of the exact position
of vessels ought to be devised for the set of vessels that are being berthed/moored in a
particular section. A berth plan is called a master scheduling service in Lean logistics
terminology. While carrying out port formalities after a vessel is moored and to perform
unloading and loading operations, handling equipment is assigned. The cargo handling
operations are influencing by the number of ships in port, the quantity of port equipment,
and the human resources available.

According to UNCTAD, loading and unloading operations can be performed in three
ways. The first way is a direct delivery or direct cargo transfer in which cargo or
containers are transferred into land modes immediately, avoiding any additional activities
such as yard and storage. While terminal managers, in this way, will be released from
yard stacking management, bottlenecks may result in the quay area, which eventually
may delay vessel-unloading operations. In a second way, known as indirect operations or
cargo transfer, quay cranes unload cargo onto the quay to be transported by prime movers
to assigned storage positions within the terminal. This option implies additional costs for
cargo transfer. The third way is a mixture of the former two and is the focus of this
research by mapping the value stream of port operations.
5.4.3. VSM for Port Operations

Against other mathematical modeling tools, VSM provides the flexibility to build models of complex real-life systems with systematic occurrences, such as handling equipment breakdowns and eliminate the effect of these occurrences along the entire process. VSM can be used to describe process steps as they are performed in real life and investigate customer service. VSM is generally effective as an optimization technique that aims to find the optimal and best solution to a process problem. The optimal solution made by VSM consists of the values of decision variables and waste identification that satisfy certain constraints within operation processes under which the objective function attains a maximum value.

To improve productivity and capacity at Umm Qasr Port, and because many decisions cannot be taken by using the techniques of traditional operations research, Lean concept can be used for container terminal operations as a means of analysis. After operation processes have been mapped by the current VSM, the future VSM can be used to prepare cargo-handling activities to run on the basis of just-in-time. This approach can be performed when sub-processes and activities run on an individual basis that allows improvement of sub-processes separately. The next step is to bring all sub-processes together and run the whole process. Such an approach enables the terminal to improve its service quality, flexibility, flow, short lead-time and short cycle-time. It also helps terminal operators to anticipate problems that may occur during a normal operation such as planning imbalances and failures in order to apply the culture of total productive maintenance through the establishment of a maintenance schedule. This may be seen as an opportunity to reduce vessel waiting time and equipment breakdowns during unloading operations.

In addition, Takt time can be calculated with the help of VSM by measuring customer demand. Takt time is the average time taken to successfully complete a certain task. It contributes to the overall efficiency and effectiveness of the port as demanded by port customers, as well as controlling the master service schedule and arranging port inventory effectively. By measuring the average time that container terminal processes and sub-processes need to be completed, the operators can have control over them and precise instruments to modify any deviations can be applied. Using a just-in-time system
to run a container terminal enables operators to offer different services and serve different markets and trades without bottlenecks taking place between them. The allocation of human resources and equipment, the control of storage yard space and the management of terminal inventory, which means control of ship time in port, contribute to identifying possible wastes that may influence the performance of vessels and to creating a set of emergency measures.

This puts VSM at the container terminal operations service; therefore, a good connection is introduced with the outside environment especially with modes of surface transport. This is extremely important because the Lean ports network and Lean port concept depends on mura (unevenness) and muri (overburdening) concepts for the on-time implementation and planning of terminal and port resources.

Considering a broader approach when investments are made outside and within a Lean port and terminal environment, VSM can help to plan and design a terminal’s capacity and its respective layout, identify the type and quantity of equipment to be used, and define the equipment parameters, such as handling speeds, that contribute to an increase in productivity and to a cost reduction in the proposed investment. Overall, VSM can improve the overall performance and value chain of ports and Lean port networks, which, in the extreme, could result in process automation as a means to overcome the high costs of port labor. In order to identify the waste within Umm Qasr port operation processes and measure environmental wastes, VSM has been produced with the number of items of equipment used to handle containers and time spent for each part of the process for both current VSM and Future VSM as illustrated by Figures 24 and 25.
Figure 4: Current Value Stream Map for Container Terminal
Figure 2: Future Value Stream Map for Container Terminal
5.5. Measuring Working Time Efficiency, Carbon Dioxide CO2 emission and Energy Consumption by using Footprint Analysis

While the carbon footprint concept is closely attached to CO2 emissions and global warming are created by specific consumption activities or produced by human, no consensus has been attained regarding how to quantify or measure carbon footprints. The "Footprint" term is frequently presented as a general word for measures highlighting the utilized human beings natural resources (Carbon Trust, 2007). A concept of Footprint can be a useful measure to illustrate how the activities of human beings cause various types of impacts and burdens and have a noticeable effect on the development of global sustainable (BP, 2007).

This measures, footprint, are often calculated in area units, other measures are usually defined in units of area such as the sustainable environmental performance indicator (SEPI), sustainable development index (SPI), and ecological footprint (EF) (Grubb and Ellis, 2007). While, units of area may not necessarily be the measurement of other footprint kinds. As quantitative indicator, Carbon footprint is expressing the quantity of GHG gasses emissions contributing to global warming and climate change (EC, 2009).

Usually, the carbon footprint is equal to the carbon dioxide quantity and other GHG gasses produced by a product or process during their entire life cycle (UK Post, 2006).

Wiedmann and Minx (2008) presented the carbon footprint as a measure of CO2 emissions created indirectly or directly by a product or an activity throughout all stages of its life cycle and can be applied to processes, individuals, groups, businesses, governments, organizations and industrial sectors. A carbon footprint cannot be represented as a unit of area (hectares, square meters) because CO2 emissions appear in mass units (kilograms, tons). A Carbon footprint, as the total amount of gaseous CO2 and other GHG gases created by a process or product life-cycle, can be defined as grams of CO2 equivalent per kilowatt-hour of electricity (g CO2 eq / kWh), and also reflects the effects of various GHG gases on global warming (UK Post, 2006).

Since moving one container from a vessel until its departure from the port involves the operation of handling equipment, including ship-to-shore (ST) operation by gantry crane, quay transfer operation (QT) by terminal tractors, yard operation (YO) by reach stackers and gate operation (GO) by external trucks, one import container’s carbon footprint in a
container terminal can be quantified as the total CO2 emissions by the four types of equipment. In order to implement the methodology of footprint analysis the following formula is used to measure the carbon footprint of one container movement:

5.5.1. Formula

\[
TCO2 = ST\_CO2 + QT\_CO2 + YO\_CO2 + GO\_CO2
\]

\[
ST\_CO2 = ST\_AEC \times ST\_CC
\]

\[
QT\_CO2 = QT\_AEC \times QT\_CC
\]

\[
YO\_CO2 = YO\_AEC \times YO\_CC
\]

\[
GO\_CO2 = GO\_AEC \times GO\_CC
\]

Where:

- TCO2: Total Co2 emission from all equipment (kg)
- AEC: Average energy cost of one piece of equipment (kWh/L)
- CC: CO2 emission coefficient (kg)
- ST_CO2: Total CO2 emissions from Ship to Shore operation (kg)
- ST_AEC: Average energy cost for one gantry crane (kWh/L)
- ST_CC: CO2 emission coefficient (kg) of gantry crane
- QT_CO2: Total CO2 emissions from Quay transfer operation (kg)
- QT_AEC: Average energy cost for one terminal truck (kWh/L)
- QT_CC: CO2 emission coefficient (kg) of terminal truck
- YO_CO2: Total CO2 emissions from Yard operation (kg)
- YO_AEC: Average energy cost for one reach stacker (kWh/L)
- YO_CC: CO2 emission coefficient (kg) of reach stacker
- GO_CO2: Total CO2 emissions from Gate operation (kg)
- GO_AEC: Average energy cost for one truck (kWh/L)
- GO_CC: CO2 emission coefficient (kg) of truck

5.5.2. Data Collection

CO2 emission and Energy cost data from port operations from March to October 2016 were collected from port data and formulas used by two options (i.e. existing value stream map and future value stream map). The first part of this research compared four different container terminal operating areas on the basis of green port assessment criteria,
which included working time efficiency, energy consumption cost, and CO₂ emissions. The container terminal has 16 TTs to perform container-handling tasks. The size of the terminal is standard container terminal size, which consists of a quay length of 400 meters yielding overall terminal size of roughly 285,400 square meters (equivalent to 28.54 hectares). Each of the two gantry cranes performs 18-23 moves per hour and two mobile cranes perform 14-18 moves per hour.

In order to measure the carbon footprint of one container in a container terminal, assumptions by (Yang, 2015) and (author, 2016) on a number of hypothetical conditions were made, namely (1) container movements are limited to the movements of import containers, rather than of export containers or transshipment containers; (2) container movement areas are composed of a berth area, container yard, and gate area; (3) in terms of operating efficiency, the gantry crane with 21 moves per hour is faster than the mobile crane with a working efficiency of 16 moves per hour according to the collected data from the port, and, therefore, requires 2.86 minutes for one move of gantry crane (i.e., 60 minutes/21 moves=2.86 minutes/move) and 3.75 minutes for one move of other type (i.e., 60 minutes/17 moves=3.75 minutes/move); and (3) one export container movement is considered a continuous action for the purpose of carbon footprint calculation, and sailing schedule is not taken into consideration.

With regard to criteria of green port assessment and based on variables gathered from an extensive literature review, working time efficiency (time consumed by each movement), energy consumption cost and CO₂ emissions (CO₂ emissions of one piece of equipment) are used to measure the green container terminal performance of the handling equipment.

5.5.3. Empirical examination (Carbon footprint perspective)

Employing a carbon footprint perspective, this paper compared the four main types of cargo handling equipment at the four case companies from the perspective of carbon dioxide reduction, working efficiency, and energy consumption cost based on data collected from four case study companies from March to October of 2016. Based on the assumption that electric equipment in the standby condition does not waste energy, it was assumed that each piece of equipment was in the consecutive operation mode, and total
working time was calculated as the output of annual operation divided by the average equipment working efficiency of each type. The total equipment energy consumption of each type was calculated as the total working time of this specific equipment multiplied by the energy consumption per hour of that equipment. The average energy consumption of equipment was calculated as the equipment's total energy consumption divided by the quantity of equipment. Finally, the CO2 emissions of equipment were obtained from average energy consumption for that equipment multiplied by the CO2 emission coefficient. For instance, in the case of reach stacker, according to information published by the Taiwan Power Corporation and Chinese Petroleum Corporation, CO2 emissions are 2.7 Kg CO2/L for diesel power and 0.637 Kg CO2/kWh for electric power in 2014. Using this data, the study found that average CO2 emissions for one container are 16.68 kg for scenario number one based on existing VSM and 12.1 kg for scenario number two based on future VSM.

\[
\begin{align*}
ST_{CO2} &= ST_{AE} \times ST_{CC} \\
&= 1.782 \text{ L} \times 2.67 \text{ kg/L} = 4.76 \text{ kg} \\
QT_{CO2} &= QT_{AE} \times QT_{CC} \\
&= 0.594 \text{ L} \times 2.67 \text{ kg/L} = 1.59 \text{ kg} \\
YO_{CO2} &= YO_{AE} \times YO_{CC} \\
&= 6 \text{kWh} \times 0.637 \text{ kg/kWh} = 3.82 \text{ kg} \\
GO_{CO2} &= GO_{AE} \times GO_{CC} \\
&= 2.41 \text{ L} \times 2.7 \text{ kg/L} = 6.51 \text{ kg} \\
TCO2 &= ST_{CO2} + QT_{CO2} + YO_{CO2} + GO_{CO2} \\
&= 4.76 \text{ kg} + 1.59 \text{ kg} + 6.51 \text{ kg} + 3.82 \text{ kg} = 16.68 \text{ kg}
\end{align*}
\]

A container terminal space can be divided into the berth area, container yard, and gate area. The researcher conducted interviews with experts in charge of terminal operations at the selected port during the stated period concerning working time data for one container movement in the container berth area, yard area, and gate area. In addition, each container movement involves the use of four types of handling equipment (gantry crane, internal tractor, yard crane and external tractor) as the container is transported from the container ship through the berth area and stacking yard to the gate area.
As Table 21 and Figure 26~28 show green port assessment criteria including working time, energy consumption cost and CO2 emission are discussed as follows:

First of all, in terms of working time efficiency, the working time efficiency of four operation models in container terminals based on ranking order of the size shown BL (23.86 minutes) and AL (21.89 minutes). AL’s operation mode energy consumption accounted for 21.89 minutes, which is lower than 23.86 minutes for BL. Obviously, AL’s operational efficiency is higher than BL. The improved process can handle container handling operations across different block areas. Improving operation process by eliminating process waste and value added activities leads to time efficiency. Moreover, reducing the number of items of container handling equipment while achieving the same throughput target, reduces CO2 emissions and energy consumption.

The future value stream map for container terminal operation highlights the benefits of waste elimination and non-value added activities. Indeed, terminal equipment could be used in 24-hour operation. Working speed conditions were set up in compliance with Standard Operation Process (SOP), which result in AL’s operational efficiency being higher than that of BL. Strong equipment mobility can handle many containers across different block areas. The terminal uses reach stacker and terminal tractors for yard operations, which may not be considered as the most efficient cargo-handling model comparing with straddle carriers, Rubber Tire Gantry Crane (RTG) and Rail Mounted Gantry Cranes (RMG). Although RMGs cannot move as rapidly or operate as efficiently as straddle carriers and RTGs, RMGs with electric power usage can meet the requirement of environmental protection for energy saving and CO2 reduction, and its storage capacity is greater than the other two types. However, the focus of this study is on improving the operation process based on eliminating waste within the existing process and not to recommend investment in new cargo handling equipment.

Secondly, in terms of energy consumption cost, the energy cost for one container in four different operating models is based on the ranking order of the size BL (2.143 US$) and AL (1.25 US$). According to the technical report of Umm Qasr Port (2015), the energy cost accounted for approximately 4.2 kWh by one container. Gantry cranes and mobile cranes are required electric power to move containers from vessels to the terminal
tractors while reach stackers and terminal tractors are using diesel oil to operate. Therefore, as they demanded diesel oil for operation, energy consumption cost is higher than gantry cranes.

Thirdly, in terms of carbon footprint, carbon emissions generated by one import container handling in four different modes, shows in Table 27 that the ranking order of CO2 emission figure were BL (16.68 Kg)＞ AL (12.11 Kg). Due to the use of diesel oil, the terminal handling equipment could spend more energy cost and cause higher CO2 emission.

Figure 26: Working time efficiency of different operating models and scenarios
Figure 26 indicates that the working time efficiency for the ship-to-shore operation process of a container ship is much better than other operation processes so that the contribution of the new scenario of Lean implementation is less than other parts of operation. The gain of implementing Lean for a container ship in regards to working time efficiency for the ST, QT, YO and GO operations represent 4%, 27%, 8% and 5% of working time efficiency respectively. Obviously, the quay transfers and yard operation processes are more affected by the process inefficiency based on the waste of transportation, waiting, motion and overproduction. The yard operation includes several changeovers between processes and involves several players that have direct impacts on the process efficiency.

Figure 27: Energy consumption cost of different operating models and scenarios
Similarly, as can be seen in Figure 27, the energy consumption costs show the direction of comparison lines, which indicate that significant gains would be achieved by implementing the Lean approach. The gains of energy consumption costs for the ST, QT, YO and GO represent 32%, 43%, 15% and 25% respectively. It reveals that reducing the energy consumption costs varies from one part of the operation process to another according to how many pieces of equipment are involved to perform each process.

Figure 28: Carbon dioxide emissions of different operating models and scenarios

The carbon dioxide emission shows noticeable gains in reducing the emissions by implementing Lean as shown in Figure 28.
Table 22: Summary of four operating models and two scenarios carbon footprint measurement (Container Handling).

<table>
<thead>
<tr>
<th>Assessment criteria</th>
<th>Before Lean BL</th>
<th>After Lean AL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Working time efficiency (Minutes)</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>Days</td>
<td>310.4</td>
</tr>
<tr>
<td></td>
<td>Energy Consumption cost US$</td>
<td>1.596.436</td>
</tr>
<tr>
<td></td>
<td>Carbon dioxide emission (Kg)</td>
<td>12.426</td>
</tr>
<tr>
<td></td>
<td>Tons</td>
<td>Kg</td>
</tr>
<tr>
<td></td>
<td>Working time efficiency (Minutes)</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>Days</td>
<td>272.7</td>
</tr>
<tr>
<td></td>
<td>Energy Consumption cost US$</td>
<td>931.192</td>
</tr>
<tr>
<td></td>
<td>Carbon dioxide emission (Kg)</td>
<td>9.021</td>
</tr>
<tr>
<td></td>
<td>Tons</td>
<td>Kg</td>
</tr>
</tbody>
</table>
As mentioned earlier, the calculations are carried out per unit of cargo handled for each part of the cargo handling process (see Table 22). In order to illustrate the benefits of Lean implementation, real data for the year of 2015 has been considered to quantify the total gains per year. The annual Lean implementation gains reveal that the concept of Lean would encourage the port management to adopt this management technique to overcome the existing operation process problems.

As a multifunctional port, in 2013 Umm Qasr Port handled around 4 million tons of dry bulk cargo such as wheat, sugar, rice, barley, corn, and soybeans. Obviously, handling this type of cargo requires different types of cargo handling equipment such as Vigan pneumatic equipment for unloading wheat with diesel engines, trucks, mobile cranes and bobcat bulldozers. There are two ways of handling wheat at Umm Qasr Port based on the delivery system used and storage facilities. The silo berth is equipped with unloading equipment that is connected directly to a conveyor belt to transfer the imported wheat from the vessel to the storage silos with a capacity of 60 thousand tons. This system is supposed to be more efficient because of the available storage capacity and smooth flow of cargo between the vessel and storage facilities. However, this berth was built 40 years ago and is still operating with the same equipment without upgrading, which consequently leads to low efficiency. The second way of handling wheat is using portable vegan unloading machines that unload the wheat from vessels directly to external trucks without storing this cargo inside port storage facilities.

The analysis and calculations that are shown in Table 23 focused on the second way because many types of environmental wastes were generated such as GHG emissions, dust, and noise as well as the energy consumption value. Due to the lack of data related to other than CO₂ emissions and also to follow the same pattern in this analysis, the footprint analysis of the dry bulk terminal will take the CO₂ emissions, energy consumption cost and working time efficiency as the base of calculation relying on the current and future VSM that were previously illustrated. Similarly, the general cargo handling and RORO are calculated in Tables 24 and 25 respectively, taking into consideration the differences of cargo handling equipment and the operation process.
Table 23: Summary of four operating models and two scenarios carbon footprint measurement (Dry Bulk Handling)

<table>
<thead>
<tr>
<th>Assessment criteria</th>
<th>Total for the year of 2015 as example 2,442,645 tons</th>
<th>Total Per Ton</th>
<th>ST Per ton</th>
<th>QT Per ton</th>
<th>YO Direct operation</th>
<th>GO Per ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working time efficiency (Minutes)</td>
<td>157.9 Days</td>
<td>12.92</td>
<td>2.5</td>
<td>7.16</td>
<td>0</td>
<td>3.26</td>
</tr>
<tr>
<td>Energy Consumption cost US$</td>
<td>2,100,674</td>
<td>0.86</td>
<td>0.14</td>
<td>0.61</td>
<td>0</td>
<td>0.11</td>
</tr>
<tr>
<td>Carbon dioxide emission (Kg)</td>
<td>17,538 Tons</td>
<td>7.18</td>
<td>3.37</td>
<td>2.52</td>
<td>0</td>
<td>1.29</td>
</tr>
<tr>
<td>Working time efficiency (Minutes)</td>
<td>117.77 Days</td>
<td>11.4</td>
<td>2.39</td>
<td>6.58</td>
<td>0</td>
<td>2.43</td>
</tr>
<tr>
<td>Energy Consumption cost US$</td>
<td>1,819,770</td>
<td>0.745</td>
<td>0.128</td>
<td>0.51</td>
<td>0</td>
<td>0.107</td>
</tr>
<tr>
<td>Carbon dioxide emission (Kg)</td>
<td>15,804 Tons</td>
<td>6.47</td>
<td>3.33</td>
<td>2.23</td>
<td>0</td>
<td>0.91</td>
</tr>
</tbody>
</table>
Table 24: Summary of four operating models and two scenarios carbon footprint measurement (General Cargo)

<table>
<thead>
<tr>
<th>Assessment criteria</th>
<th>Total for the Year of 2015 As example 1,917,606 Tons</th>
<th>Total Per Ton</th>
<th>ST Per ton</th>
<th>QT Per ton</th>
<th>YO Per ton</th>
<th>GO Per ton</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before Lean (BL)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working time efficiency (Minutes)</td>
<td>202.1 Days</td>
<td>17.52</td>
<td>3.17</td>
<td>4.49</td>
<td>4.55</td>
<td>5.31</td>
</tr>
<tr>
<td>Energy Consumption cost US$</td>
<td>1,802,550</td>
<td>0.94</td>
<td>0.116</td>
<td>0.59</td>
<td>0.08</td>
<td>0.154</td>
</tr>
<tr>
<td>Carbon dioxide emission (Kg)</td>
<td>13,596 Tons</td>
<td>7.09</td>
<td>2.06</td>
<td>2.14</td>
<td>1.65</td>
<td>1.24</td>
</tr>
<tr>
<td><strong>After Lean (AL)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working time efficiency (Minutes)</td>
<td>182.44 Days</td>
<td>14.92</td>
<td>2.92</td>
<td>4.17</td>
<td>3.72</td>
<td>4.11</td>
</tr>
<tr>
<td>Energy Consumption cost US$</td>
<td>1,591,613</td>
<td>0.83</td>
<td>0.112</td>
<td>0.514</td>
<td>0.073</td>
<td>0.131</td>
</tr>
<tr>
<td>Carbon dioxide emission (Kg)</td>
<td>12,618 Tons</td>
<td>6.58</td>
<td>1.92</td>
<td>2.05</td>
<td>1.44</td>
<td>1.17</td>
</tr>
</tbody>
</table>
Table 25: Summary of four operating models and two scenarios carbon footprint measurement (RORO)

<table>
<thead>
<tr>
<th>Assessment criteria</th>
<th>Total for the Year of 2015 As example 183340 Units</th>
<th>Total Per Ton</th>
<th>ST Per ton</th>
<th>QT Per ton</th>
<th>YO Per ton</th>
<th>GO Per ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Lean BL</td>
<td>Working time efficiency (Minutes) 166.88 Days</td>
<td>7.97</td>
<td>2.22</td>
<td>1.78</td>
<td>0.36</td>
<td>3.61</td>
</tr>
<tr>
<td></td>
<td>Energy Consumption cost US$ 80.670</td>
<td>0.44</td>
<td>0.07</td>
<td>0.23</td>
<td>0.04</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Carbon dioxide emission (Kg) 1.234 Tons</td>
<td>6.73</td>
<td>2.33</td>
<td>2.2</td>
<td>1.11</td>
<td>1.09</td>
</tr>
<tr>
<td>After Lean AL</td>
<td>Working time efficiency (Minutes) 148.11 Days</td>
<td>7.38</td>
<td>1.94</td>
<td>1.66</td>
<td>0.29</td>
<td>3.49</td>
</tr>
<tr>
<td></td>
<td>Energy Consumption cost US$ 73.886</td>
<td>0.403</td>
<td>0.066</td>
<td>0.21</td>
<td>0.036</td>
<td>0.091</td>
</tr>
<tr>
<td></td>
<td>Carbon dioxide emission (Kg) 1.168 Tons</td>
<td>6.37</td>
<td>2.26</td>
<td>2.08</td>
<td>1.02</td>
<td>1.01</td>
</tr>
</tbody>
</table>
Table 25: Total Gains by implementing Lean based on suggested future VSM

<table>
<thead>
<tr>
<th></th>
<th>Container</th>
<th>Dry Bulk</th>
<th>General Cargo</th>
<th>RORO</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working time</td>
<td>37.7</td>
<td>40.13</td>
<td>19.66</td>
<td>18.77</td>
<td></td>
</tr>
<tr>
<td>Efficiency Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Consumption</td>
<td>665.244</td>
<td>280.904</td>
<td>210.937</td>
<td>6.784</td>
<td>1.163.869</td>
</tr>
<tr>
<td>Cost US$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>3.404</td>
<td>1.734</td>
<td>978</td>
<td>660</td>
<td>6.776</td>
</tr>
<tr>
<td>Emission Tons</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To summarize the gains of Lean implementation on Umm Qasr Port operation processes, Table 26 indicates that the working time for the container terminal would be reduced by 37.7 days for the same traffic of the year of 2015 by using the same resources. In other words, the container terminal may handle 15 vessels more by improving the operation process resulting in generating more revenues and increasing terminal throughput as well as reducing waiting time for container ships. The port record indicates that the container terminal make about USD200.000- USD250.000 per container ship with container handling charges which means that the port’s annual earning will increase by USD3 million- USD3.75 million. Similarly, the bulk terminal working time is reduced by 40.13 days allowing the port to handle 7 more vessels per year. While the general cargo terminal is reduced by 19.66 days, 9 more ships could be handled with the same facilities.
and resources. RORO terminal operation process improvement contributes to the working time efficiency by reducing the time 18.77 days allowing the port to handle 26 RORO vessels more as these types of vessels need less than 24 hours to unload their cargo.

Essentially, the energy consumption cost is one of the expensive expenses of port operation costs especially when the energy is generated from light diesel, which is the case of Umm Qasr Port. Implementing the Lean approach on the port operations assist the port in minimizing the process waste and subsequently using the cargo handling equipment efficiently. Moreover, the improved operation process uses fewer resources by eliminating unnecessary transportation between different processes and unneeded motion within the same process. Table 25 illustrates clearly the energy consumption costs saving by implementing Lean based on the suggested scenarios. For a port to reduce the energy cost by USD1.163,869 per year, this would give the port the flexibility to reduce the cost of services, which will encourage more customers to use port facilities as the service cost is lower and the quality of service improved by process improvement. Reducing the energy consumption has more benefits than only financial savings; Greenhouse Gases Emissions will be reduced as a consequence of reducing energy consumption. The calculation results concluded that more than 6700 tons of carbon dioxide emission would be eliminated from the total emissions generated by different port operations. Such contribution by Umm Qasr Port to global environment protection is considered a significant contribution that would be made by Iraq as a country to the United Nations efforts of reducing GHG emissions.

5.5.4. Significance of Statistics (T-Test)

There is the need to establish that there is statistical significance between the differences in measurements pre-Lean and post-Lean. Given that this is such a specific and unique case study, “demonstrable” and valid process improvement is necessary and indicating statistical significance will support this. In other words, practical significance has been established in the work, but its statistical equivalent that assures that the purported differences are not random, is important. The quantitative analysis results need to be properly supported by statistical significance evidence to prove that the results are significant in terms of t-test statistics. In order to examine the significance and reliability of statistics a t-test is used.
which is defined as a statistic that tests the reliably difference of two means (averages) from each other.

A difference can be seen when looking at the means, but the results cannot make sure if that is a reliable difference. There are statistics, such as a mean, that describe available data but cannot be generalized beyond that description. There are statistics, such as t-tests, which can be used to allow the analysts to make inferences about the population beyond their data. In order to check whether the measurement of working time efficiency, energy consumption cost and carbon dioxide emission is reliable and significant, an independent-samples t-test was used to check the effectiveness of using the Lean approach. Table 26 summarizes the t-test results for the three variables for both scenarios: BL and AL.

The T-test has been defined as “A t-test’s statistical significance indicates whether or not the difference between two groups’ averages most likely reflects a “real” difference in the population from which the groups were sampled” (Statwing, 2017). The test is normally used by researchers to illustrate whether the groups of data are significant or not in order for them to construct concrete findings of research work. From the literature review on the T-test notes for a significant data test, the significance value has to be less than 5% otherwise the group test would indicate insignificant test and the results considered unreliable.
Table 27: Descriptive Statistics calculations for Working Time Efficiency

<table>
<thead>
<tr>
<th></th>
<th>Group (A)</th>
<th>Group (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alpha (for confidence interval)</strong></td>
<td><strong>5.00%</strong></td>
<td><strong>5.00%</strong></td>
</tr>
<tr>
<td>Count</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Mean</td>
<td>4.15133</td>
<td>3.42467</td>
</tr>
<tr>
<td>Mean LCL</td>
<td>2.40836</td>
<td>1.791</td>
</tr>
<tr>
<td>Mean UCL</td>
<td>5.8943</td>
<td>5.05833</td>
</tr>
<tr>
<td>Variance</td>
<td>9.9061</td>
<td>8.70263</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.1474</td>
<td>2.95002</td>
</tr>
<tr>
<td>Mean Standard Error</td>
<td>0.81265</td>
<td>0.76169</td>
</tr>
<tr>
<td>Coefficient of Variation</td>
<td>0.75816</td>
<td>0.8614</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>0.36</td>
<td>0.29</td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td>13.5</td>
<td>12.9</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>13.14</td>
<td>12.61</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>3.26</td>
<td>2.92</td>
</tr>
<tr>
<td><strong>Median Error</strong></td>
<td>0.26298</td>
<td>0.24649</td>
</tr>
<tr>
<td><strong>Percentile 25% (Q1)</strong></td>
<td>2.36</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>Percentile 75% (Q3)</strong></td>
<td>4.93</td>
<td>3.915</td>
</tr>
<tr>
<td><strong>IQR</strong></td>
<td>2.57</td>
<td>2.115</td>
</tr>
<tr>
<td><strong>MAD (Median Absolute Deviation)</strong></td>
<td>0.09</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Coefficient of Dispersion (COD)</strong></td>
<td>0.6182</td>
<td>0.59521</td>
</tr>
<tr>
<td>Mean Deviation</td>
<td>2.14693</td>
<td>1.77893</td>
</tr>
<tr>
<td>Second Moment</td>
<td>9.24569</td>
<td>8.12245</td>
</tr>
<tr>
<td>Third Moment</td>
<td>50.00795</td>
<td>53.31376</td>
</tr>
<tr>
<td>Fourth Moment</td>
<td>536.48155</td>
<td>548.80065</td>
</tr>
<tr>
<td>Sum</td>
<td>62.27</td>
<td>51.37</td>
</tr>
<tr>
<td>Sum Standard Error</td>
<td>12.18981</td>
<td>11.42538</td>
</tr>
<tr>
<td>Total Sum Squares</td>
<td>397.1889</td>
<td>297.7619</td>
</tr>
<tr>
<td>Adjusted Sum Squares</td>
<td>138.68537</td>
<td>121.83677</td>
</tr>
<tr>
<td>Geometric Mean</td>
<td>3.1886</td>
<td>2.56719</td>
</tr>
<tr>
<td>Harmonic Mean</td>
<td>2.10769</td>
<td>1.69253</td>
</tr>
<tr>
<td>Mode</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>Skewness</td>
<td>1.77881</td>
<td>2.30308</td>
</tr>
<tr>
<td>Skewness Standard Error</td>
<td>0.54006</td>
<td>0.54006</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>6.2759</td>
<td>8.31841</td>
</tr>
<tr>
<td>Kurtosis Standard Error</td>
<td>0.89214</td>
<td>0.89214</td>
</tr>
<tr>
<td>Skewness (Fisher's)</td>
<td>1.98288</td>
<td>2.56729</td>
</tr>
<tr>
<td>Kurtosis (Fisher's)</td>
<td>5.24232</td>
<td>8.17515</td>
</tr>
</tbody>
</table>
Table 28: Test statistics and P-level for working time efficiency

<table>
<thead>
<tr>
<th>Compare Means</th>
<th>Descriptive Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAR</td>
<td>Sample size</td>
</tr>
<tr>
<td>A</td>
<td>15</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
</tr>
</tbody>
</table>

T-test assuming unequal variances (heteroscedastic)

| Degrees of Freedom | 28 |
| Hypothesized Mean Difference | 0 |
| Pooled Variance | 9.30436 |
| Test Statistics | 0.55241 |

Two-tailed distribution

| p-level | 0.02946 Critical Value (5%) | 2.04841 |

One-tailed distribution

| p-level | 0.01973 Critical Value (5%) | 1.70113 |

G-criterion

| Test Statistics | 0.05644 Critical Value (5%) | 0.17900 |
| p-level | 0.02810 |

Pagurova criterion

| Ratio of variances parameter | 0.53234 |
| Test Statistics | 0.55241 Critical Value (5%) | 0.06327 |
| p-level | 0.03519 |
Table 29: Descriptive Statistics calculations for Energy Consumption cost

<table>
<thead>
<tr>
<th>Group (A)</th>
<th></th>
<th>Group (B)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>15</td>
<td>Count</td>
<td>15</td>
</tr>
<tr>
<td>Mean</td>
<td>0.2922</td>
<td>Mean</td>
<td>0.22853</td>
</tr>
<tr>
<td>Mean LCL</td>
<td>0.12191</td>
<td>Mean LCL</td>
<td>0.11469</td>
</tr>
<tr>
<td>Mean UCL</td>
<td>0.46249</td>
<td>Mean UCL</td>
<td>0.34238</td>
</tr>
<tr>
<td>Variance</td>
<td>0.09456</td>
<td>Variance</td>
<td>0.04226</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.3075</td>
<td>Standard Deviation</td>
<td>0.20558</td>
</tr>
<tr>
<td>Mean Standard Error</td>
<td>0.0794</td>
<td>Mean Standard Error</td>
<td>0.05308</td>
</tr>
<tr>
<td>Coefficient of Variation</td>
<td>1.05236</td>
<td>Coefficient of Variation</td>
<td>0.89956</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.04</td>
<td>Minimum</td>
<td>0.036</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.13</td>
<td>Maximum</td>
<td>0.64</td>
</tr>
<tr>
<td>Range</td>
<td>1.09</td>
<td>Range</td>
<td>0.604</td>
</tr>
<tr>
<td>Median</td>
<td>0.154</td>
<td>Median</td>
<td>0.13</td>
</tr>
<tr>
<td>Median Error</td>
<td>0.02569</td>
<td>Median Error</td>
<td>0.01718</td>
</tr>
<tr>
<td>Percentile 25% (Q1)</td>
<td>0.105</td>
<td>Percentile 25% (Q1)</td>
<td>0.0999</td>
</tr>
<tr>
<td>Percentile 75% (Q3)</td>
<td>0.41</td>
<td>Percentile 75% (Q3)</td>
<td>0.36</td>
</tr>
<tr>
<td>IQR</td>
<td>0.305</td>
<td>IQR</td>
<td>0.261</td>
</tr>
<tr>
<td>MAD (Median Absolute Deviation)</td>
<td>0.038</td>
<td>MAD (Median Absolute Deviation)</td>
<td>0.018</td>
</tr>
<tr>
<td>Coefficient of Dispersion (COD)</td>
<td>1.26277</td>
<td>Coefficient of Dispersion (COD)</td>
<td>1.06256</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Deviation</td>
<td>0.23749</td>
<td>Mean Deviation</td>
<td>0.17065</td>
</tr>
<tr>
<td>Second Moment</td>
<td>0.08825</td>
<td>Second Moment</td>
<td>0.03945</td>
</tr>
<tr>
<td>Third Moment</td>
<td>0.04121</td>
<td>Third Moment</td>
<td>0.00787</td>
</tr>
<tr>
<td>Fourth Moment</td>
<td>0.03569</td>
<td>Fourth Moment</td>
<td>0.00357</td>
</tr>
<tr>
<td>Sum</td>
<td>4.383</td>
<td>Sum</td>
<td>3.428</td>
</tr>
<tr>
<td>Total Sum Squares</td>
<td>2.6045</td>
<td>Total Sum Squares</td>
<td>1.3751</td>
</tr>
<tr>
<td>Adjusted Sum Squares</td>
<td>1.32379</td>
<td>Adjusted Sum Squares</td>
<td>0.59168</td>
</tr>
<tr>
<td>Geometric Mean</td>
<td>0.18861</td>
<td>Geometric Mean</td>
<td>0.16002</td>
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<td>Harmonic Mean</td>
<td>0.132</td>
<td>Harmonic Mean</td>
<td>0.11736</td>
</tr>
<tr>
<td>Skewness (Fisher's)</td>
<td>1.75211</td>
<td>Kurtosis (Fisher's)</td>
<td>1.1199</td>
</tr>
<tr>
<td>Kurtosis Standard Error</td>
<td>0.54006</td>
<td>Kurtosis Standard Error</td>
<td>2.29585</td>
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<td>Kurtosis</td>
<td>4.5826</td>
<td>Kurtosis</td>
<td>0.89214</td>
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<tr>
<td>Skewness</td>
<td>1.5718</td>
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<tr>
<td>NaN</td>
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<td>NaN</td>
<td></td>
</tr>
</tbody>
</table>
Table 30: Test statistics and P-level for Energy Consumption Cost

<table>
<thead>
<tr>
<th>VAR</th>
<th>Sample size</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15</td>
<td>0.2922</td>
<td>0.30750</td>
<td>0.09456</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
<td>0.22853</td>
<td>0.20558</td>
<td>0.04226</td>
</tr>
</tbody>
</table>

**t-test assuming unequal variances (heteroscedastic)**

| Degrees of Freedom | 24       |
| Hypothesized Mean Difference | 0       |
| Pooled Variance     | 0.06841  |
| Test Statistics     | 0.66663  |

**Two-tailed distribution**

| p-level | 0.04114 Critical Value (5%) | 2.06390 |

**One-tailed distribution**

| p-level | 0.02557 Critical Value (5%) | 1.71088 |

**G-criterion**

| Test Statistics | 0.07517 Critical Value (5%) | 0.17900 |
| p-level         | 0.01202                      |

**Pagurova criterion**

| Ratio of variances parameter | 0.69110 |
| Test Statistics              | 0.66663 Critical Value (5%) | 0.06336 |
| p-level                      | 0.04886 |
Table 31: Descriptive Statistics calculations for CO₂ Emissions

<table>
<thead>
<tr>
<th></th>
<th>Alpha (for confidence interval)</th>
<th>Group (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group (A)</strong></td>
<td></td>
<td>Count 15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean 2.512</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean LCL 1.66630</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean UCL 3.35770</td>
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<tr>
<td></td>
<td></td>
<td>Variance 2.33213</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standard Deviation 1.52713</td>
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<tr>
<td></td>
<td></td>
<td>Mean Standard Error 0.39430</td>
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<td></td>
<td></td>
<td>Coefficient of Variation 0.60793</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minimum 1.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maximum 6.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Range 5.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median 2.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median Error 0.12760</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percentile 25% (Q1) 1.44</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percentile 75% (Q3) 2.945</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IQR 1.505</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAD (Median Absolute Deviation) 0.08000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coefficient of Dispersion (COD) 0.48224</td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group (B)</strong></td>
<td></td>
<td>Count 15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean 2.102</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean LCL 1.53086</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean UCL 2.67314</td>
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<td></td>
<td></td>
<td>Variance 1.06366</td>
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<tr>
<td></td>
<td></td>
<td>Standard Deviation 1.03134</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean Standard Error 0.26629</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coefficient of Variation 0.49065</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minimum 0.91</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maximum 4.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Range 3.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median 2.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median Error 0.08617</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percentile 25% (Q1) 1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percentile 75% (Q3) 2.695</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IQR 1.495</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAD (Median Absolute Deviation) 0.13000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coefficient of Dispersion (COD) 0.39285</td>
</tr>
</tbody>
</table>
Table 32: Test statistics and P-level for CO2 Emissions

<table>
<thead>
<tr>
<th>VAR</th>
<th>Sample size</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15</td>
<td>2.512</td>
<td>1.52713</td>
<td>2.33213</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
<td>2.102</td>
<td>1.03134</td>
<td>1.06366</td>
</tr>
</tbody>
</table>

**t-test assuming unequal variances (heteroscedastic)**

- Degrees of Freedom: 25
- Hypothesized Mean Difference: 0
- Pooled Variance: 1.69790
- Test Statistics: 0.86171

**Two-tailed distribution**

- p-level: 0.03970

**One-tailed distribution**

- p-level: 0.01985

**G-criterion**

- Test Statistics: 0.09513
- p-level: 0.01067

**Pagurova criterion**

- Ratio of variances parameter: 0.68677
- Test Statistics: 0.86171
- p-level: 0.04027
Table 3: T-test results for the three variables for both scenarios BL and AL.

<table>
<thead>
<tr>
<th>Working time efficiency</th>
<th>Energy Consumption cost</th>
<th>Carbon dioxide emission</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL</td>
<td>AL</td>
<td>BL</td>
</tr>
<tr>
<td>13.5</td>
<td>12.9</td>
<td>0.22</td>
</tr>
<tr>
<td>2.86</td>
<td>2.07</td>
<td>1.13</td>
</tr>
<tr>
<td>6.00</td>
<td>5.5</td>
<td>0.62</td>
</tr>
<tr>
<td>1.5</td>
<td>1.42</td>
<td>0.173</td>
</tr>
<tr>
<td>2.5</td>
<td>2.39</td>
<td>0.14</td>
</tr>
<tr>
<td>7.16</td>
<td>6.58</td>
<td>0.61</td>
</tr>
<tr>
<td>3.26</td>
<td>2.43</td>
<td>0.11</td>
</tr>
<tr>
<td>3.17</td>
<td>2.92</td>
<td>0.116</td>
</tr>
<tr>
<td>4.49</td>
<td>4.17</td>
<td>0.59</td>
</tr>
<tr>
<td>4.55</td>
<td>3.72</td>
<td>0.08</td>
</tr>
<tr>
<td>5.31</td>
<td>4.11</td>
<td>0.154</td>
</tr>
<tr>
<td>2.22</td>
<td>1.94</td>
<td>0.07</td>
</tr>
<tr>
<td>1.78</td>
<td>1.66</td>
<td>0.23</td>
</tr>
<tr>
<td>0.36</td>
<td>0.29</td>
<td>0.04</td>
</tr>
<tr>
<td>3.61</td>
<td>3.49</td>
<td>0.1</td>
</tr>
</tbody>
</table>

P-Value = 0.03519
Significance Value

P-Value = 0.04886
Significance Value

P-Value = 0.04027
Significance Value
According to the findings of the T-test, the groups of data are significant as the significance values for the working time efficiency; energy consumption cost and carbon dioxide emission are 0.03519, 0.04886 and 0.04027 respectively. As mentioned earlier, the acceptable significance value must be less than 0.05 so that the findings of the t-test reveals that the calculations of working time efficiency, energy consumption cost and carbon dioxide emission are significant to the research findings.

5.5.5. Gray relation analysis GRA

The main reason for using the gray GRA as a method for data processing was its ability to determine the degree correlation between the influencing factors in a system with the uncertain information (Deng, 1988). Wang, et al., (2004) indicated that GRA enables the researchers to select the most representative indicators and then sort the initial assessment indicators to avoid small sample size restrictions.

In the first step of the analysis, Deng initiated the formula of gray relational grading which includes the four axioms, which are divided into two parts using traditional methods (Wen, 2004):

1. Gray relational coefficient

\[ \gamma(x_0(k), x_i(k)) = \frac{\Delta_{\text{min}} + \zeta \Delta_{\text{max}}}{\Delta_{oi}(k) + \zeta \Delta_{\text{max}}} \]

Where

(a) \( i = 1,2,3,\ldots \), \( m \), \( k = 1,2,3,\ldots \), \( n \), \( j \in i \)
(b) \( x_0 \): Reference sequence, \( x_i \): Inspected sequence.
(c) \( \Delta_{oi} = |x_0(k) - x_i(k)| \): The difference between \( x_0 \) and \( x_i \) (norm)
(3) \( \zeta \): distinguishing coefficient

According to Yang (2015), the main purpose of \( \zeta \) is to adjust the difference between \( \Delta_{o,i} \) and \( \Delta_{\text{max}} \). While \( \zeta \) can be assigned any desired value, it is usually assigned the value of 0.5. It has been illustrated in a proof of a mathematical theorem that the rank of the gray relational grade will not be changed by a change in the value of \( \zeta \).

(4) After the gray relational grade has been calculated, Gray relational rank order can rank the sequence in accordance with the value. This procedure yields the gray relational rank. For reference sequences \( x_0 \) and inspected sequences \( x_i \), where

\[
x_0 = (x_0(1), x_0(2), \ldots, x_0(n)), x_i = (x_i(1), x_i(2), \ldots, x_i(n)), \]

if \( \gamma = (x_0, x_i) \geq \gamma(x_0, x_j) \) it was found that with the reference sequence

\( x_0 \), the gray relational rank of \( x_i \) is greater than that of \( x_j \).

The raw data for these criteria with respect to the considered two container terminal CT operating models (e.g. BL and AL) are listed in Table 33. The mean value of these criteria weights (including working time efficiency: WTE, energy consumption cost:
ECC and CO$_2$ emission: CDE) were used to perform gray relational analysis, and to calculate the difference between the reference sequence and inspected sequence. Gray relational grade values are given in Tables 33–35 respectively. The ranking order of CT operating models based on gray relational analysis was AL (0.992) > BL (0.732).

For understanding the computation procedure of GRA easily, the paper gave a clear illustration of analysis steps of GRA in the following:

- As comparability was satisfied by the original data, data processing was not needed.
- By using $\Delta(k) = |x_0(k) - x_i(k)|$.

Where $i = 1, 2, 3, 4$ and $k = 1, 2, 3$.

(1) $\Delta_{01}(1) = 23.86$ $\Delta_{01}(2) = 2.143$ $\Delta_{01}(3) = 16.68$

(2) $\Delta_{02}(1) = 21.89$ $\Delta_{02}(2) = 1.25$ $\Delta_{02}(3) = 12.11$

then we have (1)$\Delta_{01}=(0, 48.23, 3.83)$ (2)$\Delta_{02}=(0.61, 0, 0)$

- The max. equals $48.23$ and min. equals $0.00$
- Taking $\zeta = 0.5$
- By using gray relational formula.

(1) Relational coefficient calculation:

$$\gamma \left( x_i(k), x_j(k) \right) = \frac{\Delta_{\text{min}} + \zeta \Delta_{\text{max}}}{\Delta_{ij}(k) + \zeta \Delta_{\text{max}}}$$

Substituting the values of max. and min. into
\[ \gamma(x_0(k), x_i(k)) = \frac{0+(0.5)\times(48.23)}{\Delta_0(k)+0.5\times(48.23)} \]  

then:

(a) \( \gamma(x_0(1), x_1(1)) = 1.000 \)  
\( \gamma(x_0(2), x_1(2)) = 0.333 \)  
\( \gamma(x_0(3), x_1(3)) = 0.873 \)

(b) \( \gamma(x_0(1), x_2(1)) = 0.975 \)  
\( \gamma(x_0(2), x_2(2)) = 1.000 \)  
\( \gamma(x_0(3), x_2(3)) = 1.000 \)

(2) Calculating the gray relational grade \( \gamma(x_0, x_i) = \frac{1}{3} \sum_{k=1}^{3} \gamma(x_0(k), x_i(k)) \), we have:

(a) \( \gamma(x_0, x_1) = \frac{1}{3} (1 + 0.321 + 0.873) \approx 0.746 \)

(b) \( \gamma(x_0, x_2) = \frac{1}{3} (0.969 + 1.000 + 1.000) \approx 0.986 \)

(3) Ranking the rank: According to the relational grade, the rank is

\( AL (0.986) > BL (0.746) \)

### Table 34: Raw data

<table>
<thead>
<tr>
<th></th>
<th>WTE</th>
<th>ECC</th>
<th>CDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference sequence</td>
<td>23.86</td>
<td>1.25</td>
<td>12.11</td>
</tr>
<tr>
<td>BL</td>
<td>23.86</td>
<td>2.143</td>
<td>16.68</td>
</tr>
<tr>
<td>AL</td>
<td>27.32</td>
<td>1.25</td>
<td>12.11</td>
</tr>
</tbody>
</table>

### Table 35: The difference between reference sequence and inspected sequence

<table>
<thead>
<tr>
<th></th>
<th>WTE</th>
<th>ECC</th>
<th>CDE</th>
<th>MAX</th>
<th>MIN</th>
<th>ζ</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL</td>
<td>0.00</td>
<td>48.23</td>
<td>3.83</td>
<td>48.23</td>
<td>0.00</td>
<td>0.5</td>
</tr>
<tr>
<td>AL</td>
<td>0.61</td>
<td>0.00</td>
<td>0.00</td>
<td>0.61</td>
<td>0.00</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Table 36: Gray relational grade values

<table>
<thead>
<tr>
<th></th>
<th>WTE</th>
<th>ECC</th>
<th>CDE</th>
<th>GRD</th>
<th>RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL</td>
<td>1</td>
<td>0.321</td>
<td>0.873</td>
<td>0.746</td>
<td>2</td>
</tr>
<tr>
<td>AL</td>
<td>0.969</td>
<td>1</td>
<td>1</td>
<td>0.986</td>
<td>1</td>
</tr>
</tbody>
</table>

To conclude the outcome of this study, the research intends to answer the question: What is environmental waste within port processes? Environmental waste is an excess or unnecessary use of resources or a substance released to the air, water, or land that could affect human health or harm the environment. Environmental wastes can be created when a port uses resources to provide services to clients or when clients use and dispose of products.

The main findings based on the carbon footprint approach reveals that the ranking order of CO$_2$ emission volume for the first scenario (BL) is greater than the second scenario (AL). Secondly, AL can be considered a green scenario due to its significant contributions to CO$_2$ reduction, energy saving, and working efficiency. A green and Lean port concept should be designed to harmonize cargo handling operations with the ecological environment by striking a balance among CO$_2$, energy saving, and working efficiency. The main focus of this study is on improving the operation process through waste elimination and utilizing cargo-handling equipment efficiently. However, for a newly built port the latest technology can be adopted and the purchase of new equipment, which is with low GHG emissions and cost effective. After carrying on this empirical analysis, this study found the following conclusions:

First, there are two options to address environmental wastes within the port process by either mapping the operation processes and identify environmental wastes according to Lean seven deadly wastes or mapping the environmental process specifically and identify the seven deadly wastes directly. As this research attempts to produce a three pillar framework, the methodology used was to map the operations processes and identify
different types of wastes. Further research can be undertaken to draw the water process value map, chemicals handling process value map, dumping dredging materials process value map, sewage handling, garbage handling, ballast water management and management of hazardous cargo. Obviously, there are more elements than those to be considered when examining the port environmental system but limitation of data availability led to identifying only eight elements.

Second, using Lean techniques for improving the operation process can reduce the environmental hazards, energy cost and increase the working time efficiency by identifying wastes and eliminating them from the process without investing in new facilities or equipment. The comparison between the two scenarios illustrated that the ranking of Lean implementation was better than the existing situation for the three footprint analysis elements.

Third, Lean Energy Management provides the service delivery process with an immediate and reliable method of observing how much energy is being consumed by cargo handling equipment, offices, and cars. Consuming more energy than needed generates environmental waste that has a significant impact on human health as well as increases the associated costs to be paid by the port and its customers. There are many reasons for integrating Lean with energy efficiency such as cost savings, greenhouse gas management, environmental risks and competitive advantage.

Forth, the empirical examination in this chapter was focused on footprint analysis of four operations models and four types of cargo handling operations. The outcome of this examination confirmed that the container handling operations generate more CO2 emissions and consume more energy compared to other types of operations.

Finally, the analysis and measurements were calculated per container for container terminals and per ton for dry bulk, general cargo, and RORO. The data was collected directly from the port operations during the abovementioned period and average working time was computed for various vessels.
6. Chapter Six: Discussion and Results

6.1. Establish a continuous work culture

Most organizations that attempt Lean transformations focus solely on the value optimization pillar through the use of waste reduction and value optimization tools such as 5S and value stream mapping. Organizations that do not support an equal if not greater focus on the respect for people pillar will not be successful with Lean. Leveraging the value of knowledge, creativity, experience, and ideas of port employees contribute significantly to establishing a continuous process improvement culture. Implementing Lean can initially lead to apparent worse results on traditional financial statements, such as a reduction in inventory appearing to be a reduction in assets. Therefore, the initial stages of a Lean implementation require a commitment from top management and a long-term time horizon. In order for the port to implement Lean, the working culture must take serious action to cease dependence on inspection to achieve quality. Creating quality into the service in the first place should eliminate the need for inspection. Furthermore, the system of service providing should be constantly improved to improve quality and productivity, and thus constantly decrease costs.

A successful continuous improvement culture requires effective involvement of people by breaking down barriers between port departments that are engaged in service providing directly or indirectly. People in management, planning, operation, and monitoring must work as a team, to foresee problems of service providing that may be encountered with the service. For a port newly introduced to the Lean concept, the port management needs to put every individual in the port to work to accomplish the transformation, which is everybody's job. In order to get quality of service right the first time, they need to become unafraid of creating a continuous process flow to build a culture of stopping to fix problems and bring problems to the surface. The management needs to thoroughly understand that standardized tasks are the foundation for continuous improvement and employee empowerment. It is important to develop exceptional people and teams who follow port’s philosophy in order to focus on their Lean training at the beginning of project implementation. They may become the leaders to carry on the
project and training courses for other employees. On the other, port management needs to respect port’s extended network of partners and customers by challenging them and helping them improve, as they are important part of port processes.

Successful Lean implementation and transformation mainly depend on respect for people culture. If this is not taken into consideration by port management, a fail in implementation will be caused. The employees and customers of port must be aware of what the activities the port is offering currently, what things they want to do in the future and what steps they would need to accomplish in order to achieve the roadmap they have created. The opposite scenario is when there are absences of methods that are widely interpreted for linking information flow throughout the port. Currently, employees do not anticipate what is expected performance of them, how they have to do their jobs, what is the current state of working process, and top management of the port is not often check and is perceived to be unaware of what is going on.

In Umm Qasr port, locating a suggestion box has created a suggestion program; however, implementation of suggestions is sporadic and unpredictable. There is little confidence by the employees that suggestions will be reviewed and implemented; therefore, there is little incentive to make suggestions. For better employee involvement in the continuous process of improvement culture, a sustainable suggestion program need to be implemented, which gives employees confidence that their suggestions are being reviewed in a timely manner and will be implemented if appropriate. The port receives at least one suggestion per year per employee, and if over 60% of employees’ suggestions are considered, it would be a perfect start creating a continuous improvement culture.

Port management may assure that should be a clear policy in place for information sharing and knowledge management as well as an established network of knowledge databases to all employees. Competitive and customer information is actively harvested from outside of the organization and is compiled into meaningful and actionable data. Knowledge management is a key component of leadership team activities as the knowledge intranet needs to be accessible by employees throughout the entire organization and is being extended to customers and partners because access to knowledge leads to rapid decision-making. The port management considers the
knowledge of ground workers as available port resources to the integrated service value chain throughout the delivery process from operation to the customer. This knowledge of employees flows across inter-boundaries and intra-boundaries of port organization freely unencumbered and knowledge must be considered as a shared resource, not guarded.

While collecting data from the port operations, the researcher found that generally the leadership team spends most of time in their offices. Many operation problems are assessed based on meetings, conversations, and reports far from the real location of the problem occurrence. Problem resolution and decisions are very quick but comprehending only what is obvious and often results in unintended consequences. Members of the Port operation management team are sparing a sufficient portion of time on the terminal facilities; however, significant number of ground workers do not know the aims of those visits because there is little interaction and communication occur. The better understanding and visibility of process improvement are directing to developed decision-making process, which is rarely realized by terminal employees and port customers. Go to Gemba has experienced as a common practice by operation management team members in operations yards and facilities for successful Lean enterprise and this is important practice for the port’s Lean team. Port operation management team members need to have an intense understanding of the current circumstances at the Gemba (real life) and to start implementing the methods of Lean to challenge the current value stream process. When a problem occurs, investigation committee is encouraged to carry on the investigation process at the Gemba. Go to Gemba are preferred to be a daily practices by all management members of the port as well as members of improvement group and take place in both administrative and operations sections. These Go to Gemba practices establish a significant understanding of the existing operation process and also teaching all concerned people how to see and eliminate process wastes. Teams of problem investigation and process improvement always present at the source of the problem. Port workers, and especially management team, necessarily require to make frequent insight tours throughout the operation processes to ensure that an intimate knowledge of the whole processes by all parties is achieved.
During Go-gemba practice made by the author, it has been realized that there is very limited teamwork management orientation. The managers initiate most port activities, especially programs for improvement, and the operators and administrative people implement the managers’ new ideas. The managers need to realize that every port’s employee has a significant position on a team and it is very important that no employee ever misses a team important meeting or activities. Obviously, There should be a number of successful works achieved throughout the port that must be highlighted to be considered as successful practice. Each teamwork needs to have a specific introducing name, a standard methodology, and clear goals in order to assess their progress over periods of time to ensure team activities continuous improvement. The assessment of employee performance is preferred to be measured by project and responsibility success rather than only by the amount of time put in. The port may offer support systems, such as daycare and healthcare, which advocates helping employees maintain maximum focus on the job while also relieving them of home issues.

The research findings reveal that there is recognition of the need for increased knowledge in certain key areas but professional internal and external training is still seen as a cost. Cross training of operation team members has begun in an attempt to offset the impact of absenteeism but this attempt is insufficient to improve processes. The port can start to create an organized training program for all levels of the port departments. Cross training of operation, management and quality control team members are seen as a way to increase agility and improvement of ideas. Key employees may be selected to attend Lean conferences and return to share their new knowledge on Lean implementation. To encourage effective involvement of port employees, the Lean team needs to define different types of awards by creating a reward system for individual, team, and port performance. The reward system may include both financial and non-financial compensation depending on the reward strategy. The gain-sharing program and other reward programs need to be dynamically viewable by all employees of the port and thoroughly defined.

It has been proved earlier in this research that improvements in the port are uncoordinated and occasional, and mostly a process failure reaction. In addition, there has not been
considerable training in process improvement methods and the operators in each department have not mapped their process, identified value-added and waste activities, and are rarely initiating improvements. Difficult to find formal process analysis methods are used to identify potential waste elimination and time reduction opportunities. Therefore, the Lean implementation has to start from the very beginning with concept introduction and training prior to commencement of project implementation.

The next step of implementation is to create a formal value stream organizational structure in order to be implemented throughout the entire organization. Lean implementation indicates the advantages of aligning cargo-handling equipment along the maps of value streams and attempts are being made to reduce cargo transport and minimize yards sizes. Physical boundaries between shipping agencies, the port, and cargo receivers must become blurred when drawing the future value stream processes taking place where they are most effective.

Figure 29: Suggested agenda for a three-day value stream mapping

The main purpose of mapping the value stream is to identify the waste and non-value added activities within port processes from the port and customers’ perspectives. Therefore, the port Lean team together with port customers define the waste that need to
be eliminated and draw the future value stream. Involving all concerned parties in the Lean implementation and process improvement encourages everyone to participate in continuous improvement until it becomes a working culture. The success in implementation must be celebrated and evaluated in order to further the improvement processed by the Lean team. Further action needs to be taken on the implementation plan by the port based on the future value stream map that may be carried out with the port management to carry on a 3–day Value Stream Mapping and a 5-day Kaizen Event based on Figure 29 and Figure 30.

Figure 30: Suggested Agenda for a five-day Kaizen Event
6.2. Reducing the Complexity of Port Processes

For the selected port, variability and complexity are seem to be normal occurrences in the business development and the finding of this research reveals that they are addressed by additional oversight processes, which will create additional opportunities for failure and more complexity. Variability and Complexity are now seen by the finding of this research as attributes to be minimized in order to work according to takt time. Different Programs have been used by many organizations to address the issue via value stream mapping, Lean manufacturing, and facility optimization. The ability of port management to simplify complexity and variability in operation processes is seen as a key leadership competency, which requires training and hiring criteria including a focus on these attributes. The impact of operational and support methods on complexity are key service and process design criteria. The reduction of port operation process complexity and variability, and the ability to adeptly manage the remaining, is a significant competitive advantage with measurable return. In order to successfully achieve this reduction, formal methods have to be developed to identify and minimize complexity throughout all processes of the port operation.

The findings of this research reveal that there is absence of documented and defined management methods and procedures to be followed by concerned parties allowing unplanned decisions to add even more complicity in the existing processes. This leads to inconsistency with operational and administrative processes where employees loss their confident on what is expected of them. Even though, some key operation processes of port are defined and documented but revising them is considered as a bureaucratic process and time-consuming because these changes are seen reactions to unexpected problems. If the Process time is also unpredictable and unmeasured, it will be leading to unreliable and inaccurate commitments to customers. Critical parameters and operations are not properly documented and there is minimal change control to the procedure. Some processes are becoming more stabilized by container terminal operators on some occasions; however, setup time can be highly variable and parameter interaction is not well understood.
In order to keep the process simplified, service providing procedures need to be defined and documented; however, they should not be kept subject to interpretation, which creates non-conformances and other quality issues. Therefore, parameter ranges have to be created and validated to define optimal operating windows for port customers. To simplify the operation processes of the selected port, all operations processes need to be accurately documented and implement the standardization is seen as important.

In order to eliminate process complicity and variability, all process activities require standardization of performance that is easily changed and followed to allow the implementation of continuous improvements of the operation process. This also necessitates all managers to instruct standard work to guarantee consistent review of key interactions, metrics, and operations. Process requirements and steps have to be defined and communicated to the port partners, customers and organization, to ensure common expectations and consistency. Operational opportunities and problems are evaluated with modifications made to those standards by the Lean implementation team.

Operations and administrative processes should also be appropriately defined, documented and stabilized by complying with the value stream map when a new customer or employee need to understand critical attributes, processes, and operations. With the documented operation process being frequently updated, the root cause understood and instability and exceptions are immediately investigated. Common Lean best practices, documentation, reporting methods, and standards across the extended value stream may successfully be used.

The investigations of port operations have shown that most problems are reacted to, however, little effort is made to avoid problems from reoccurring because the need for root cause analysis has not been identified and several people have not received external training on how to proactively handle the problems. All manufacturing quality problems generate a thorough root cause analysis that creates true preventative action. Formal root cause methodology is being rolled out to the non-manufacturing functions such as 5-whys root cause analysis. Any operational or administrative problem can be a good reason to use a root cause analysis within port processes to prevent future problem occurrence. The port management should have all employees being trained on how to identify wastes,
and all being involved at least once on a root cause analysis. The port’s emphasize on root cause analysis needs to be integrated into key customers to establish preventative plan covering the entire value stream map.

6.3. Effective Process for Environment Protection and Energy Management

For successful Lean implementation by a port, employees’ ability to identify and eliminate process waste is considered to be a cornerstone of Lean environmental initiatives. However, environmental waste is a type of process waste that is often under addressed or ignored by Lean initiatives. Environmental wastes may lead to high costs to port business when they are grouped together, including disposal cost, raw material cost, and costs for activities of compliance management and equipment of pollution control.

The emphasis on Lean eliminating waste and non-value added activity has a perfect impact on decreasing the volume of material, energy, chemical, water wastes and usage, creating significant environmental benefits and competitiveness. During Lean implementation, the full lifecycle impacts and the environmental risk that materials pose to the environment and human health are rarely considered. The ability to identify environmental wastes during implementing Lean efforts would provide important process improvement opportunities for port operations, further improve environmental performance, and strengthen Lean implementation results.

Normally, operational process environmental wastes are often an indication of an inefficient service providing process, and frequently opportunities for cost savings and reducing time are pointed out handling chemicals and hazardous cargo by terminal operators often require costly support activities and facilities, such as the use of personal protective equipment, reporting activities and regulatory compliance management, and the investment of equipment for pollution control, operating them, and regular maintenance. These environmental wastes can create unnecessary risks to workers’ health and safety as well as adding no value to the customers of the port. Therefore, the elimination of these process wastes provides significant benefits for the port employees, customers and partners. Process improvement and other Lean strategies can reduce the impact of such waste and non-value added activities. Subsequently, learning how to
identify and eliminate environmental wastes is an excellent attempt to improve the quality, time, and reduce cost results of Lean implementation.

The environment protection leadership team of Umm Qasr Port can be seen energetic with environmental activities only when a serious pollution takes place or when there is an external audit. The environmental waste cost or value is not a part of port management decision-making authority as the responsibility of environment protection has been designated to a department outside the control of the port authority. The leadership team needs to develop a metrics to measure environmental impact and work on programs to reduce the impact of waste. In order to cover a wider range of environment protection efforts, the leadership team has to be aware of community and social issues impacting the operation and provide public input and support where appropriate because environmental responsibility is a key performance measurement attribute for the leadership team. There are multiple executive level programs to minimize the environmental impact of the port operations by implementing Lean, above and beyond what is required by law and regulations.

Lean implementation requires that all Lean team are involved in Lean implementation projects that eliminate the port’s environmental waste impact. Port employees need to be supported financially and encouraged to participate in port environmental programs initiated by Lean implementation. The Lean environment protection team may actively promote environmental awareness within the port activities and to customers and employees. The Lean environment protection team has to be involved with waste elimination practice actively, including social and environmental programs at the port city level because ports are parts of the entire environment performance of the country.

The Port of Umm Qasr has not officially documented, frequently updated, and communicated objectives and goals on how to protect the environment and manage the energy efficiently. Strategic plans for the next years have to be developed based on the intuition and knowledge of the Lean leadership team as well as international standards. These plans must be communicated to the rest of the port processes; however, the plans and especially the rationale must be well understood by relevant players. Initial Hoshin Kanri can be used to initiate a meaningful environment protection and energy
management policy. Hoshin methods are being used by Lean organizations to align long-term strategic goals with three-year breakthrough objects, and then to current year annual improvement programs. These programs have to include accountability, and span multiple value streams for operation processes. It should be assured that all employees understand the key goals and the role they play in their success of environment protection and waste elimination. Hoshin Kanri methods as part of Lean implementation are normally applied to align the short-term and long-term corporate, individual goals, and value stream across the entire value stream map from employees to customers for both port operations and environment protection.

Lean manufacturing has become a very integral part of many Lean enterprises’ business successes both in manufacturing and service sectors. In the future of these enterprises, survivability of economy will require delivery of businesses for customers to be actively engaged in Lean and green best practices. For a Lean port, it will be very easy to become green as the port processes collaborate in creating value and taking initiatives to eliminate process waste as well as minimizing the consumption of resources. In other words, the path for the port to become a Lean port will lead this port to become green. Both Lean and Green port is considered to be integrated organization that focuses on eliminating process waste by reducing the resource consumption in order to effectively create value for customers. Energy consumption reduction result in saving money, shrink environmental footprint, which have been proven in Chapter 5.

6.4. Implementing Pull System

In the production sector, inaccurate demand forecasts result in either shortage of spare parts supply or excessive finished goods inventory. Service is sometimes created in anticipation of port customers’ future demand for cargo handling and port facilities. Therefore, concerted efforts need to be made to match service-providing resources to actual customer demand. In order to comply with Lean thinking by changing the mentality from the push to pull system, demand-based pull services have to be set up with key clients. When the cycle times of service delivery are being radically reduced, creating the ability to respond very quickly to new demand and working according to designed
takt time. All service providing processes and administrative processes need to be driven by pull methods and takt time of a process is synchronized with demand. Most activities occur at levels of one-piece flow that can be managed by a Kanban system from the port customer through the operation back to the shipping lines.

A successful pull system assists the management believing the port has sufficient competencies and understand what the port customer demands and insists on providing its service with this policy. It was revealed that a considerable time of port management is consumed playing politics with port customers to ensure the operation is in control and study their needs carefully in order for the leadership team to understand the importance of customer input and to make a point of defining the port’s value from the perspective of the customer. Each leadership team member spends at least three weeks per year visiting customers and high level of trust and informality is required to be created between the port and key customers. This level of trust and interaction creates a significant competitive advantage, which may lead to some technical, and service positions being co-funded by the port and the customer. In order to implement a successful Lean, the port customers should be allowed to be more active in all key decisions of port operations, and even can be co-located at the port’s boundary. By implementing the pull system, the limit between the port, partners, and customers would be hidden and the entire value stream normally perform as a single consistent entity.

On the other hand, the information industry is formally evaluated in regular bases by port management together with port customers and is part of key decision-making. This can be achieved through finding systems that exist to actively implement Lean methods and find shipping industry and competitors’ information where growth is identified and considered as an input into port future plans. In order to assess the demand, it is advisable to have an existing multiple active forensic programs to make a realistic forecast and track the activities of potential competitors as well as the trends shipping and port industry. Such information has to be dynamically and constantly reviewed for those trends because they are key component of port management decision-making process.

Apparently, there are no metrics for Umm Qasr Port that exists, which can be actively improve and measure process value from the customer perspective. While it is necessary
for a Lean port to have identified various metrics, such as cycle time, financial performance, and on-time shipment.

6.5. Five S (Sort, Set in Order, Shine, Standardize and Sustain)+ Safety

The Lean approach focuses on the cleanliness of workplaces, yards, offices and all the working facilities in order to remove all obstacles that may cause delays, stoppage and accidents. The best Lean tools to facilitate this goal is 5S which was formally defined by the Japanese as an approach of maintaining workplace clean and orderly by making abnormalities immediately visible and expose waste. As such it is important to realize that 5S is far more than a housekeeping initiative like so many used to be (Ohno, 1988). When someone refers to 5S, 5 Japanese words that start with S are generally referred to. However, it would seem, contrary to what many people assume, the origins of 5S may not be Japanese after all. In fact, Henry Ford’s CANDO program which stands for cleaning up, arranging, neatness, discipline, and ongoing improvement seems to be the obvious precursor to what we call 5S today (Pereira, 2014). In fact, this appears logical because after the World War II ended, the Japanese studied Ford’s methods. However, the focus for this research on 5S like in most Lean manufacturing situations takes into consideration the 5 Japanese words that are defined by Ohno, (1988):

- Seiri which is commonly translated as sort
- Seiton which means to straighten
- Seisou which means to sweep or shine
- Seiketsu which actually means to sanitize but is most commonly referred to as standardize today
- Shitsuke which means self discipline or sustain

The 5 Steps according to Womack and Jones (2003):

1. The first step is sort. To sort simply means to remove unnecessary items from the workplace that no longer add value. This step basically challenges us to get rid of the
things that are not needed or used. This can be a very hard step for some people since they like to keep everything they have ever come into contact with. However, this type of attitude only leads to clutter and disorganization. So, what is not needed should be gotten rid of. No matter what the item is, in the end, the entire question is whether it is really needed or not. And as many Lean practitioners are fond of saying when it doubts is sort it out. The main reasons for taking this first step are that sorting can lead to a much safer workplace. By clearing out the items that are no longer needed, workers will have more places to work and things like trip hazards and items falling off shelves will be greatly reduced. When port workers get sorting done correctly, it will most certainly increase productivity in the office environment and workplaces.

2. The second step is straighten up. So, once the items have been cleared out, what is left does not need any straightening up. The arrangement of a place for everything, and everything in its place fits this step perfectly. According to Pereira (2014), straightening up is defined as the rearrangement of all necessary items in the best order to maximize movement economy by locating things that are in use most near to where the job is done in a designated place and clearly labeled. All that is being done in the straighten up step is asking the question what is the right place for the items used the most. In other words, straighten up does not simply mean to “put things in neat rows” as the name might imply, instead it means to find a place for everything while ensuring everything is in its place. Some actually refer to this step as “set in order”. There are many reasons for the management to carry out one straighten up step to arrange the workplaces.

First of all, once items have been organized and straightened they would be easy to find and return when workers perform their jobs in different processes. Second, straightening also makes things much easier to find, which in turn eliminates the frustration caused when searching for things. Further, a fact most people do not initially think about is that straightening up also reduces inventory since things do not get lost and the port does not buy extra things it does not need. These are few examples on how straighten up is significant on Lean implementation benefits for the port processes. However, many other reasons can be considered providing advantages as the straighten up step is basically at the core of so many important business principles and Lean such as employee morale,
quality, safety, productivity, ergonomics, standard work, inventory control, and the visual workplace. The signs and labels that are arranged during the 5S practice have to describe where materials, tools, and parts are located, which need to be close to the process they would be used in. When items are placed at point of use they are immediately available within arm’s reach of ground workers making things safer and more efficient since wasted motion, waiting, and correction are all but eliminated.

3. The third step is sweep. This step is also often referred to as shine. Formally defined in the context of 5S, sweep means to clean in such a way as to identify and remove the sources of contamination. Obviously this definition is much more than many make this step ought to be because common misunderstanding about 5S is that it is about sweeping and cleaning up, which is inaccurate. In fact, it is a much wider concept than only focusing on cleaning workplaces. There are different ways of explaining how it works: first, the employees who work in a specific workplace carry on an initial physical sweep to make everything clean by picking up trash, sweeping the floors clean, and wiping down machines and equipment. They do a visual sweep each day and notice where things are getting dirty again and during these daily sweeps they write down the reasons why the mess occurred, and take action to eliminate the causes.

Another important concept is that cleaning means inspection of the equipment and facilities. For example, if someone ever hand washed and waxed a car, there is no better way for this person to find all the little dings and dents on the car since it would be direct touching it and looking far more closely than normally. Well the exact same thing occurs in yards, workshops, offices, factories and hospitals when cleaning things. The main reason of Sweep is organizations that they struggle with the sweep or shine step often suffer from poor morale since simple things like sunlight never makes it through the grime on the windows. Furthermore, studies have shown that the environment people live and work in has a direct impact on how they behave. Another benefit of sweep is that it improves safety by reducing things like slips and falls along with a myriad of other things. Sweeping also helps companies save money since cleaning up things like oil leaks leads to repair of equipment that created the mess, which ultimately prevents
breakdowns. In fact, research has shown again and again that dirt and contamination are a chief reason for machine breakdowns, as are fluid leaks, air leaks and dirty air filters.

The first thing the port must always do during the sweep step for the workplaces is cleaning with understanding the rationale of using Lean tools to clean. In other words, they need to think about how to eliminate the cause of the dirt altogether as there are four key points they need to keep focused on:

A. The cargo handling equipment and repairing machinery are the first to be restored to good conditions, so if the workplace is a complete disaster, these items need to be cleaned up.

B. The second step is to find the sources of the filth (dirt or leakages) For example, if the forklift in the storage yard is leaking oil, the task is to find out why it is leaking and just clean it up.

C. This leads directly to the third step, which is to eliminate the root causes of the issue altogether. So, in the case of the forklift, this may mean bringing in the mechanical repairman or fixing the problem themselves.

D. Finally, the last point is to reduce the need to clean at all. Very rarely is no cleaning ever needed, but this does not mean this ideal state should not be aimed at by staying focused on finding the sources of filth and eliminating them.

According to Pereira (2014), this step seems to be the most misunderstood of all since most people assume this step simply means to grab a broom and clean up. While good old-fashioned sweeping is definitely important, this step is far more than just cleaning. The main principle behind this step is to clean to inspect. In other words, if you find yourself sweeping up the same mess day after day, you should do your best to eliminate the source of the dirt.

4. The fourth step is standardize. This step is focused on creating standards so abnormalities are easily recognized. Things like checklists and audits are very helpful to identify items, equipment and material. Also, some companies even engage in corporate 5S competitions where the monthly winner gets to hold the local 5S trophy while the last
place team gets the opportunity to partake in a brown bag lunch with the general manager of the facility as they explain their plan to improve.

In the context of 5S, standardize is simply the result of doing the first three steps properly namely sort, straighten, and sweep. In fact, many companies actually refer to it as 3S and not 5S, while some call it 4S, and yet others add safety and call it 6S While none of these are wrong or better than to excel at Lean, at a minimum, the sort, straighten, and sweep steps must be mastered. Along these lines, Taiichi Ohno, one of the chief architects of the Toyota Production System was fond of saying, “where there is no standard there can be no improvement.” In other words, if there is no consistency to the way work is done, how could one ever expect to improve it?

To look at this step from a different angle, by performing this step means making what was planned to be done visual in nature preventing any guessing involved because making things in offices, yards and workshops as visual work which is essential to 5S success by assisting everyone to be aware of what to do and how to do the work. It also helps identify when something is not right allowing to implement a countermeasure immediately. So in addition to these important facts, there is another extremely powerful reason standardization is so important. This reason is the second law of thermodynamics, otherwise known as entropy, which is a measure of the disorder in any system. In another way, entropy helps measure the energy that disperses or spreads out in a process. With this said, when sorting, straightening, and sweeping an area into a thing of beauty, it is also entropy that does its very best to undo it. So you could say that this standardize step essentially keeps its eye on entropy and helps continuously fight against it.

As a quick review, visual management is used to make it clear what is “normal”. This reduces discussion about what the standard should be. Standards can always be improved, but once a standard is set it is important to make it visual so that it is maintained. A good way to maintain and improve performance is to make the status visible.

There are many examples of visual management and standardization available including:

- Safety Crosses
- Color Coding Standards
• Standard Work Documents
• Standardized Cleaning Lists
• Location Control Marks
• Position Marks / Shadow Boards
• Standardized Filing / Diagonal Tape

5. Finally the last step is sustain or self-discipline. Formally defined, in the context of 5S, sustain means to have the commitment and self-discipline to maintain the previous four steps. The key to this step is to apply positive tension. In other words, for any improvements to sustain it must be made clear that this is how a company is intended to operate, which is almost the same with continuous improvement culture that was discussed earlier in the this research. It is similar to a rope. If a rope is pulled tightly and pulled on, there is an immediate response. Conversely, if the rope is loose and pulled on, there may not be a reaction for some time. So, it gets back to be able to identify abnormalities. With positive tension issues are identified immediately; with loose or no tension there is nothing. In the 5S overview module the concept of a rope was used to describe sustain since when you tug on a rope with no slack in it, you get an immediate response.

The first reason the sustain step is so important is it drives accountability throughout the organization because most people are far more likely to follow through with a promise when they know someone else is watching and participating in the same initiative. Second, in addition to accountability, a little friendly competition can result from the sustain step. Some techniques many companies use to keep everyone focused are not only maintaining, but also improving 5S levels. Of course this competition must be kept in check and not taken too far since, in the end, the success of the company is more important than the success of a particular work area. Finally, perhaps the most important aspect of the sustain step is the fact that the entire organization continuously learns and improves. In fact, if looking at the PDCA (Plan, Do, Check and Act) wheel, parallels to 5S can be seen. The first three steps of sort, straighten, and sweep are covered in the plan while the last two steps of standardize and sustain are covered in the check and act portions of PDCA.
There are several Lean Techniques to Sustain introduced by Periera, 2014:

- The first technique is to make clear links between 5S and SQDC metrics, which stand for safety, quality, delivery, and costs. Various graphs and charts linking 5S to other critical metrics should be in place.
- The second technique to sustain is for supervision and management to practice *genchi genbutsu*, which means to go and see for yourself. In fact, for 5S to be sustained, management must make it a point to walk the floor at least once a day to find out what problems exist and how they can support their employees.
- Another powerful technique is to implement what some call a 5-minute clean program where each and every employee cleans and tidies up for a designated period of time. Some find 5 minutes each day to be enough while some may need more and some need less. The exact time period is not as important as making sure cleaning and workplace organization becomes engrained in the daily work of all associates and not just something that happens during the annual spring-cleaning blitz.
- Next, having employees audit one another’s work area at least once a month is another excellent technique used by many companies. Of course clear guidelines and specifications as to how to score things must be made clear to avoid potential conflict. Another benefit of this technique is that employees learn from each other and are able to share best practices while offering advice to one another.
- Many companies also find that a friendly 5S competition between work areas, including front office areas, can be a great way to generate excitement around the 5S program.
- Finally, the last technique is to aim for the entire facility to be tour ready with no notice. Another more practical way of ensuring tour ready is to invite others, including key customers, to tour the facilities.
6.6. Kaizen Events

Loosely translated the word *kaizen* means to change for the better. Taking it a bit further, with *kaizen* there is actually a sense of breaking down the current process, removing the unnecessary parts, and putting it back together in an improved manner. However, to be sure, *kaizen* is not a revolutionary process where all the knowledge and experience of the past is thrown out. Rather when doing *kaizen* correctly, the current process is looked at, broken apart and put back together again, so the results should be an improved process that fully utilizes all the experience and skills of the people involved. *Kaizen* is also a cornerstone of the Lean enterprise as it works together in harmony with other Lean tools and concepts such as standard work and *heijunka*, or level loading.

In order to effectively practice *kaizen* three key philosophical concepts must be understood; they are referred to as the three Gens, sometimes called the three actuals. First, when doing *kaizen*, the *genba*, or *gemba* as it is most commonly referred to, must be consulted. The researcher practiced this when collecting data of operation processes and identifying waste by collecting first hand data observation.

The word *gemba* literally means the actual place. In other words, it is the place where the work is done. For some, the *gemba* might be the factory floor, or a construction site, or the operating room in a hospital or the cargo handling berth in a port. To be sure, the chance of *kaizen* success is much higher when going to *gemba* instead of spending all the time in a boardroom drawing on flip charts and white boards. In the same spirit, rather than looking at drawings or other forms of documentation it helps if looking at the actual parts, which is what the word *genbutsu* means. So, instead of looking at a flow chart, as an example, it is better to spend time walking and experiencing the process.

Finally, getting the facts does not mean escaping from "feelings" and "theories". Rather, it simply means getting facts that either prove or disprove ideas in a non-emotion manner and preventing bias. This is what the word *genjitsu* means that helps understanding what is really happening. Often when getting the facts, something else causing the problem can be seen, or the problem may be bigger, or smaller, than previously realized. Once the
team is armed with the facts, it will be a lot easier to convince people of the changes that should be implemented.

6.7. Lean Team Behavior

For Umm Qasr Port or any other port newly introduced to Lean implementation, the first step of starting such project is to nominate qualified people to be the Lean team and leaders. Lean leaders should know how the port service serves the customer and they have to be effectively demonstrating the following behaviors in their day-to-day tasks:

- Perceiving customers’, needs, and what they value.
- Find out the level of customer satisfaction and how the process improvement satisfies the customer.
- Implementing the proper tools for improving the effectiveness of how the port service satisfies the customer.
- Showing a continuous improvement mindset by proving that there is always a chance for process improvement.
- Presenting the results of process improvement, how they are achieved and how the resources were used effectively.
- Demonstrate a good knowledge at a macro and micro level on the value stream by knowing how the value stream satisfies the port customers.
- Encouraging the continuous improvement culture.
- Having the ability of building the Lean team work through:
  - Root cause problem solving Guidance.
  - Applying 3 Gen (Gemba, Genbutsu and Genjitsu)
7. Chapter Seven: Conclusion and Recommendations

7.1. Conclusions:
Although the Lean approach is typically applied to manufacturing by production companies such as car production, aviation and shipbuilding, Lean techniques and focus are applicable wherever there are processes to improve, including the service sector such as ports, hospitals, universities and restaurants controlling the entire supply chain. Lean is all about delivering a product or service based on what the customer needs, how much, when it is needed and where. The Lean approach is to produce more products or service with fewer resources while giving the end customers exactly what they want. Therefore, it can be concluded that Lean focus is not limited to process waste elimination but it should focus on waste elimination and enhancing value to customers.

In the Lean context, value is known as any step in the process that the customer is ready and willing to pay for similar to waste which is any step adding no value from the customers’ perspectives. In order to implement Lean successfully, each step in the port operation process should be examined critically to see where unnecessary, repetitive, and non-value-added activities might be so that they may be eliminated. Lean provides an opportunity to improve performance continuously by disseminating and deploying the vision, direction, and plans of corporate management to top management and to all employees, so that workforce at all working levels would continuously proceed according the plans. Further, feedback results should be assessed and analyzed as a part of a continuous improvement process. Lean is about preserving resources and ports pay money for resources so if they can consume fewer resources through implementing Lean methodology, it becomes profitable for the ports because they are saving money.

The intention of companies using the Lean approach is that everybody is aware of the management’s vision on process improvement so that departments do not compete against each other rather than cooperating. Resulting in Lean implementation run to successful conclusions, businesses is seen as a set of coordinated processes and are successful.

Port processes improvement must address the flow of information and materials through processes as well as the enhancement of value adding process steps that create the service for the customer. This naturally leads to improve a business process that is planned for,
operated and reviewed as any other important business process is. Lean Port is an integrated entity that focuses on the elimination of waste by minimizing the consumption of resources (both human and natural capital) to effectively create value for its customers and stakeholders. On a manufacturing floor or operation yard, waste is easy to see once it is known what to look for: excess inventory, extra steps, extra transportation, waiting, defects, excess motion and overproduction. Finding waste in product development or service development is much more challenging because the “product” of new product/service development is knowledge: knowledge about customers, knowledge about technologies and process capabilities integrated into specific knowledge about how to make a product/service - the product design. All this knowledge is hard to see. Sometimes there are physical manifestations: drawings, reports, slide sets or prototypes. However, much of the knowledge, and often the most important knowledge for value creation, resides in the minds of the individuals engaged in the process. In this research, it has been found that Umm Qasr Port has many different improvement needs for various operation processes that require the objectives and methods contained in the Lean methodology. The findings of Go Gemba observation and SERVQUAL test confirm that the quality process dimension is the most influential factor for the service quality in Umm Qasr Port. The reason for poor performance of the current practices adopted by the port is using traditional ways of information flow and decision-making process that require more time and steps within the whole process. Lack of smooth process flow possibly causes bottlenecks within the port operation that create a serious problem not only for the customer but also for the port itself. Keeping the service providing the process running is of paramount importance, regardless of the quality and productivity being delivered. The main interest was not to compare port services with other ports but rather trying to measure service quality of this specific port and customer satisfaction from the customers’ perspective because the Lean approach focuses on specific process improvement. It was also found that deployment and sustaining improvements are major issues that can be overcome by establishing a continuous process improvement culture. Critical issues include using Lean to generate cash in difficult economic times, development of data based process management systems and the use of working on improvement as a leadership development tool.
The Lean Concept has also been applied in the service environment; however, the implementation of the Lean concept in the port sector as service provider still faces more limitations because of higher variation in port processes, less foundation information for port operators on Lean implementation advantages, lack of customer demand measurement as part of the pull system and lack of references in literature. This research determines these issues by proposing, a systematic approach for calculating Takt time and how the customer demand is considered as part of operations, along with a case study in Umm Qasr Port. A step-by-step procedure for the case study demonstrates how the Lean concept helps more port decision makers to understand its benefits and how it may satisfy port customers. The idea of using the Lean approach is that a lot of the “waste” in traditional (port) processes can be reduced or avoided by using it as the “drumbeat” of port operations. If every step within the operation process produces to the drumbeat, there will be no overproduction waste, and combined with the service “pull” system a port will be able to deliver the goods in an even flow (no peaks or troughs) throughout the processes. Then the port operators will have the opportunity to reduce the Work in Progress (WIP) and lead times, while maximizing efficiency.

The calculation of takt time to create a constant pace or pulse across different port processes, which will instantly highlight capacity issues, service quality issues, synchronization among port processes issues and many others was the first attempt to use this Lean tool. Understanding takt time enables the port operators to estimate their service delivery process, process outcome and eliminate the waste of overproduction by providing services to actual customer demands. The takt time helps to develop standardized work instructions thus encouraging quality and efficiency and more importantly, it helps the port operators to set real-time targets for service delivery that show the port employees and management exactly where their output is.

The ROPMEE model to measure the service quality for Umm Qasr Port was introduced by identifying six-service quality dimensions which were used in the SERVQUAL test. The results of the SERVQUAL test emphasized that the process of vessel flow and cargo flow was graded as the most negative impact on port performance. The finding also shows that an imbalance between the port resources and their outcome requires greater attention to eliminating the impact of any negative step in the process. The research
analysis reveals that port users are dissatisfied concerning the process quality dimension followed by outcome, resources, management, environment and energy management efficiency. Therefore, the management of Umm Qasr Port needs to put more efforts on improving quality services by modifying the existing practices. The Lean approach, as previously said, provides significant method and tools for process development taking into consideration customer value as the first priority which was a significant reason for selecting the Lean approach among other abovementioned reasons.

The Lean approach focuses on increasing smooth service flow and provide powerful methods for evaluating smooth process flow and stoppage step within the operation process. While adopting Lean, ports can be considered as “value added separation from non value added centers which use sufficient techniques to eliminate waste as well as introduce tools for eliminating and measuring cost of complexity. The Lean concept, which is often referred to as Lean Manufacturing, is a philosophy of production or service process improvement through waste elimination. In other words, the Lean concept is not a destination rather it is a journey of continuous improvement, making more and using less resources. This is to satisfy company clients in a consistent manner through producing what they require when they request it by pulling products or services from the value stream engaging the limited number of resources through involving all employees in a continuous process improvement and getting it right the first time. Following an appropriate observation for the port processes, it is very important to select the proper Lean tool to be used for process improvement. In this case, it has been revealed that there is complicity and problems in the operation processes, which leads to selection of VSM for solving port problems.

Against other mathematical modeling tools, VSM provides the flexibility to build models of complex real-life systems with systematic occurrences, such as handling equipment breakdowns, which cannot be accurately identified by mathematical models, eliminating the effect of these occurrences along the entire process. VSM can be used to describe process steps as they are performed in real life and investigate customer service. VSM is generally good as an optimization technique that aims at finding the optimal and best solution to a process problem. The optimal solution made by VSM consists of the values of decision variables and waste identification that satisfy certain constraints within the
operation process under which the objective function attains a maximum value. To improve productivity and capacity of Umm Qasr Port, and because many decisions cannot be taken by using the techniques of traditional operations research, the Lean concept can be used for container terminal operations as a means of analysis. After operation processes have been mapped by current VSM, future VSM can be used to prepare cargo-handling activities to run on the basis of just-in-time. This approach can be performed when sub-processes and activities run on an individual basis that allows improvement of sub-processes separately. The next step is to bring all sub-processes together and the whole process runs. Such approach enables the terminal to improve its service quality, flexibility, flow, short lead-time and short cycle-time.

Although numerous methods are helpful for measuring port performance, they are unfortunately inadequate in identifying process waste and non-value added activities in a systematic way. Instead, managers need to use an evaluation technique to find out whether or not the port is performing efficiently then they need to implement another technique to overcome the operation constrains. This research proved that the Lean approach could be used as process waste identification method and process improvement tools, which leads to efficient operation, environment harm reduction and reduce the energy consumption. This research is the first attempt in developing a systematic quantitative methodology for assessing port operation processes by using the Lean approach.

Most studies on port performance improvement focus on only one pillar at a time such as port efficiency, social impact, competitiveness, connectivity, geographical location, economic growth and environmental protection process. This dissertation studied the benefits of the Lean Concept on the port efficiency and how such efficiency improvement can have a direct influence on environmental threats and efficient energy management. There was no such a study to provide a holistic framework for improving port performance, which can be used by other ports.

To conclude, the outcome of environment benefits of this study, the research aims to answer the questions: What is environmental waste within port processes? Environmental waste is an excess or unnecessary use of resources or a substance released to the land, air, or water that could harm the environment or human health. Environmental wastes can be
created when a port uses resources to provide services to clients or when clients use and dispose of products.

The cost analysis of value stream mapping where the process waste was identified, significant financial benefits for the port have been presented in this research. The main findings based on the carbon footprint approach reveals that the ranking order of CO2 emission volume for first scenario (BL) is greater than second scenario (AL). Secondly, AL can be considered green scenario due to its significant contributions to CO2 reduction, energy saving, and working efficiency. A green and Lean port concept should be designed to harmonize cargo-handling operation with the ecological environment by striking a balance among CO2, energy saving, and working efficiency. The main focus of this study was on improving the operation process through waste elimination and utilizing cargo-handling equipment and other resources efficiently. The reduction in energy consumption will save significant bottom-line dollars year over year and reduce the carbon footprint of the facility while improving its response to clients/customers making it more competitive.

Process improvement can have an impact not only on operation efficiency but also on the environment protection efforts as well as the energy management, which is the outcome of this research as a three-pillar framework.

Further action needs to be taken on the implementation plan by the port based on the future value stream map that might be carried out with the container terminal operator to carry on a 3 – day Value Stream Mapping and a 5- day Kaizen Event as mentioned previously.

The research suggests that improvement is most effective when approached in a holistic manner addressing improvement in all parts of the organization using a holistic Lean improvement methodology. Therefore, the research evaluated the process improvement of Lean implementation impact on three pillars: namely efficiency, environment and energy management as shown in Figure 31.
Research Limitations

The focus of this research was on the implementation of Lean on port processes in order to achieve port operation processes improvement. The five generations of ports and port agility connection to Lean would be significant to further studies as the scope of this research covers the impact of Lean on service cost, time of service delivery, environment and energy management. The port tariff structure is designed to charge for all marine services, as one package that makes the calculation of single service is difficult. Therefore, cost calculation of Lean implementation was made on cargo handling process only. The focus of this dissertation on calculating the CO2 emissions as part of
environment assessment but there are other environment elements processes evaluation would be good topic for further studies such as dumping dredging materials process, ballast water management process, sewage handling process and garbage handling process.

7.2. Recommendations:

Currently, Umm Qasr Port Management’s Decisions are made and projects developed and executed based on the most immediate financial and operational impact. Because short-term results still drive decisions, such as moving in service delivery to improve current financial results. As an overall organizational strategy becomes more defined by implementing Lean, more attention needs to be paid to long-term projects, activities and quality of service. Although significant investments are being made in projects that will require months and years to realize a positive return, port operation process improvement would show faster results without investing huge amounts of money. All port processes should be aligned purely to customer demand and no longer be changed to improve financial results only.

As implanting Lean is a strategic decision, the port authority should be willing to take the responsibility for changing the working culture from the current practices to Lean thinking in order to achieve long term results. The leadership team and the entire organization now make decisions based on improving the long-term performance of the organization. Many if not most projects may yield no near-term improvement, especially financial improvement, but will improve the long-term value creation process and the entire extended value chain is aligned to create long-term value. Lean implementation projects need to be created requiring resources from all parties of the extended value chain in order to achieve long-term results. Many of these projects may not have a tangible financial value for the port but are still recognized as valuable improvements by customers.

Obviously, workers will feel stress as conditions of culture change are nearly impossible in their minds, and the path forward is shrouded in fog. Further, tension might be experienced when they sense a gap between current reality and the ideal state of Lean
implementation, but with resources and support from leadership, employees see a clear path to move forward. Therefore, it is recommended that a Lean leader should be the source of energy that compels the organization toward action creating no stress or tension while implementing the Lean concept for process improvement. Ideal states are not documents, but ongoing dialogues that take place as leaders teach, coach, and encourage workers everyday as part of process improvement. Lean transformation must have a clear sense of where the ports are currently, as well as the ideal state to which they are heading so that employees must understand their relevance to the big picture and long-term success. After creating pictures of ideal and current states by mapping the current and future VSM, Lean leaders cannot passively hope employees will act automatically. To drive change, a Lean leader must give people the right skills and knowledge to close the gap, make tough decisions about things such as organizational structure. A Lean leader must pull people together and provide a way to cross the chasm; no one will take the leap alone. Currently, employees of Umm Qasr Port receive minimal or no performance feedback from the port management because of the absence of effective teams for performance evaluation except the traditional formal annual reviews in place for all employees using defined criteria of total throughput without any indication of performance measures.

Using the Lean approach provides a powerful tool of evaluation practice and keeps employees informed of the results of process improvement as they are an important part of the implementation project. The Lean leadership team members need to use group feedback and metrics to create more frequent or even ongoing individual and team performance management. There is a desire to make all performance feedback dynamic and continuous. The performance of individuals and teams is measured and evaluated by the entire organization or representatives from the entire organization, dynamically and continuously along the period of implementation. The performance of individuals and teams is measured and evaluated by representatives from the extended value chain in order to determine the impact of individual process improvement on the entire port.

It is recommended that the Lean leadership team members realize the importance of stopping a process that is not meeting established standards for quality or efficiency.
Attempts should be made to resolve the issues, however, obtaining the right resources and decision-makers is difficult to accept the stoppage of operations, rather they prefer to continue because they think that issue resolution takes far longer than it should. However, in a successful Lean port, everyone in key processes has the authority to stop an operation if quality or efficiency is not meeting standards and customer demand. A defined escalation procedure needs to be in place to create the ability to identify and align required resources to resolve issues as quickly and effectively as possible. Immediate and dynamic communication escalates and identifies the resources needed to resolve the issue in a standardized and methodical manner.

It is recommended that a standardized set of visual controls convey the status of metrics, projects, and key processes across the entire extended port value chain from operator to customer and these controls are reviewed daily by the entire extended organization. A set of key metrics has to be developed and published and be reviewed periodically by the leadership team. These metrics cover financial, customer value and quality, people management, and effective leadership characteristics. Key metrics are published and visible to all employees in the organization, thereby holding the leadership team accountable for results. Projects are identified and executed to improve the metrics, which require the participation of all employees. Key metrics are aligned across the extended value chain and are reviewed on an ongoing basis by all parties. Improvement projects are created that require the participation of employees from all organizations.

In the current situation of Umm Qasr Port, metrics and milestones, if available and documented, are reviewed irregularly or no more than monthly. Weekly or biweekly staff meetings attempt to create alignment, but often occur after a delay or problem has occurred. Impromptu and perhaps informal staff meetings are beginning to occur in order to review and take action on issues on a more ongoing basis. When a port decides to implement Lean, it is recommended that daily management meetings be held with the participation of the Lean leadership team and all other departments within the organization. Safety, customers, metrics performance, and projects are reviewed to ensure ongoing accountability and process improvement where issues are resolved or
action is taken, or the issue is raised to the next level of accountability. A defined daily management activity occurs across the extended value chain from operation to customer.

In order to ensure a successful Lean implementation, there should be overall assessments of continuous improvement efforts. The leadership team must discuss continuous improvement activities on a sporadic basis as part of regular staff meetings. At least one external assessment tool needs to be used to evaluate various aspects of the organization and action has to be taken based on the results of this evaluation. It is preferable that the leadership team meets at least quarterly to discuss continuous improvement activities. An external assessment from an unbiased perspective also needs to be performed on a regular basis, which is then reviewed. The results of that assessment are an input into the strategic and hoshin planning process. This periodic continuous improvement review needs to be open to all employees and customers because each department or value stream, including the leadership team, provides reports on activities to share success and obtain feedback and ideas. A team comprising members from each organization in the extended value chain from suppliers to customers should meet regularly to discuss and coordinate continuous improvement activities foreseen to be significant for improvement evaluation.

Some organizations may review metrics on a regular basis, but no corrective action is taken for poor performance, which is the case of Umm Qasr Port. There is no ownership of performance and there is considerable disagreement over the direction of process improvement. Although an overall strategy and set of performance measures is being developed, management members still favor projects that enhance their individual departments even to the detriment, overt or unintended, of the overall organization. The leadership team may have consensus on key metrics and performance projects and is perceived by the organization to be aligned. However inter-department politics still create issues that must be resolved. It is recommended that the entire organization should perceive that all leadership team members, and their staff are aligned and executing the right Lean improvement projects. Complete consensus by the leadership teams of all members of the extended value chain on key performance characteristics serves to align decision-making and execution.
To show the Lean implementation results, a dashboard of financial, operational, quality, and improvement processes needs to be published at least monthly and be reviewed by all employees. All employees will understand the impact, rationale, and desired goal for each process, as well as the role they play in achieving and improving the process. Processes are reviewed at regular intervals to ensure they align with the organization’s strategy. The extended value chain from operation to customer has a consolidated set of financial, quality, operational, and improvement metrics that are reviewed regularly by appropriate leadership team members.

It is been revealed that interactions between leadership team members and the general employee base of Umm Qasr Port have become much more frequent, leading to improved trust. However, most decisions are still made with little communication. By implementing the Lean approach, it is recommended that passionate leadership team members should try to change the culture by offering perks and insisting on more transparency. The organization’s employees appreciate the transparency of leadership team decision-making and improved communication has led to a high level of trust. Key leadership team members exhibit a passion for excellence and improvement; however, there remains some inter-department mistrust that can be overcome gradually. A high level of trust exists between all members of the extended value chain from operator to customer. Interactions between leadership team members and employees are respectful and on equal grounds. The entire extended value chain is energized with a passion for excellence.

The research findings have shown that there is no sense of urgency at Umm Qasr Port and even the smallest projects often take an extraordinary amount of time to complete – if they are very completed. Key projects and activities are given priority by the stronger members of the leadership team and those are executed quickly. However those projects may not be the most important. The leadership team and segments of the organization need to start understanding the importance of urgency. Bureaucratic barriers to speed have to be removed and emphasis should be placed on action. The solution to such problems is a sense of urgency across the entire value chain from supplier through the
organization to the customer, and rapid communication between all parties, allowing for rapid action to capitalize on new market opportunities and improvements.

Some other recommendations for Umm Qasr Port have been discovered by Lean investigations but require solutions other than Lean solutions such as:

- More containerization can reduce the damage to commodities, loss of content, delivery time, unnecessary movement of cargo, and unnecessary manpower.
- Improvement of the roads is necessary to decrease the damage of cargo, the number of accidents, and to increase the speed of cargo handling.
- Crane productivity is crucial for loading and unloading operations, which require daily inspection, regular maintenance and sufficient supply of spare parts to decrease the stoppage of cranes.
- Using IT will lead to avoiding work disconnections by provision of information such as locations of containers, destinations of containers, and conditions of receiving place.
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SERVQUAL test questions.

1. Cargo Handling Equipment are Modern
   Please select one...

2. Adequate Cargo Storage Facilities
   Please select one ...

3. Availability of skilled manpower
   Please select one ...

4. Availability of Cargo Handling Equipment
   Please select one ...

5. Adequate Port Operation System POS
   Please select one ...

6. Adequate Port Layout
   Please select one ...

7. Proper Ship Arrival Notification process
   Please select one ...

8. Processing documents with minimum delays
   Please select one ...

9. Sufficient Vessel Planning Process
   Please select one ...

10. Stabilized work schedule
    Please select one...
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| 11. | Proper Visual feedback system for port operations  
Please select one… |
| 12. | Large Changeover time between shifts  
Please select one… |
| 13. | Capabilities of providing services without delays  
Please select one… |
| 14. | Intact Cargo Operations  
Please select one… |
| 15. | Assurance of shipment and operations security  
Please select one… |
| 16. | Shorter Vessel Turnaround Time VTT  
Please select one… |
| 17. | Sufficient involvement of ground workers in improvement process  
Please select one… |
| 18. | Good Quality Assurance Measures in place  
Please select one… |
| 19. | Management Capability of Performing duties skillfully  
Please select one… |
| 20. | Efficient in operations and management  
Please select one… |
| 21. | High Level of Bureaucracy  
Please select one… |
22. Proper responsiveness for Customer Complaints
Please select one ...

23. Reliable practical problem solving process
Please select one ...

24. Proper workplace organization and reorientation of flow process
Please select one ...

25. Concerns for manpower safety in operations
Please select one ...

26. Environmentally Safe Operations
Please select one ...

27. Awareness for externality impacts
Please select one ...

28. Good reputation for reliability in the market
Please select one ...

29. Adequate Environmental Measures and Initiatives
Please select one ...

30. Efficient Energy Management System
Please select one ...
# Customer’s Expectation answers

| Column 1 | Column 2 | Column 3 | Column 4 | Column 5 | Column 6 | Column 7 | Column 8 | Column 9 | Column 10 | Column 11 | Column 12 | Column 13 | Column 14 | Column 15 | Column 16 | Column 17 | Column 18 |
|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| P1       | 5        | 6        | 7        | 5        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P2       | 7        | 6        | 5        | 7        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P3       | 5        | 6        | 7        | 5        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P4       | 7        | 6        | 5        | 7        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P5       | 5        | 6        | 7        | 5        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P6       | 7        | 6        | 5        | 7        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P7       | 5        | 6        | 7        | 5        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P8       | 7        | 6        | 5        | 7        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P9       | 5        | 6        | 7        | 5        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P10      | 7        | 6        | 5        | 7        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P11      | 5        | 6        | 7        | 5        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P12      | 7        | 6        | 5        | 7        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P13      | 5        | 6        | 7        | 5        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P14      | 7        | 6        | 5        | 7        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P15      | 5        | 6        | 7        | 5        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P16      | 7        | 6        | 5        | 7        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P17      | 5        | 6        | 7        | 5        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P18      | 7        | 6        | 5        | 7        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P19      | 5        | 6        | 7        | 5        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P20      | 7        | 6        | 5        | 7        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P21      | 5        | 6        | 7        | 5        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P22      | 7        | 6        | 5        | 7        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P23      | 5        | 6        | 7        | 5        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P24      | 7        | 6        | 5        | 7        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P25      | 5        | 6        | 7        | 5        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P26      | 7        | 6        | 5        | 7        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P27      | 5        | 6        | 7        | 5        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P28      | 7        | 6        | 5        | 7        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P29      | 5        | 6        | 7        | 5        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
| P30      | 7        | 6        | 5        | 7        | 6        | 8        | 4        | 9        | 7         | 6         | 5         | 6         | 7         | 6         | 5         | 6         | 7         | 6         |
Letter of Protest

TO: Marine Pollution Department
TO: Barwell Stevedores Company
TO: Cargo Receivers
CC: Wilhelmsen Ships Service
CC: Eships Bulkers Ltd/Charterers
CC: Harbour Master Port of Umm Qasr, Iraq
CC: Owners/Blue Sand Maritime Corp

This letter serves to protest against the stevedores that they collect from ship's like as craft papers, plastic, empty bags bringing ashore and might be blown to the sea that cause marine pollution, MV Blue Sand is not liable for any cost,

This marine pollution happen during discharging operation rice in bags in umm Qasr, Iraq port on the 07th Nov, 2012.

I hereby place Barwell Stevedores on notice for any costs, that may arises to the harbour master.

I reserve the right of my owners.

Capt. Alex X. Consolacion
Master MV Blue Sand
M/V ATLANTIK PRIDE

24. MARCH. 2012
UMM QASR

TO: STEVEDORING COMPANY
TO: WILHELMSEN AS AGENT
TO: FAEDIH ALMOSWI/AGENT
CC: ATLANTIK SHIPPING.
FM: M/V ATLANTIK PRIDE

TO WHOM IT MAY CONCERN

LETTER OF PROTEST

DEAR SIRS,

I, THE UNDERSIGNED MASTER OF M/V ATLANTIK PRIDE, KINDLY INFORM YOU THAT DURING DISCHARGING OPERATIONS DUE TO NEGLIGENT, CARELESS HANDLING OF THE CARGO BY THE STEVEDORES, TWO BUNDLES WERE FALL DOWN INTO THE SEA FROM HOLD NO: 3 ON 23. MARCH 2013 AT NIGHT SHIFT AROUND 1700 HRS LT. AND TODAY MORNING DIVER’S TEAM TRY TO TAKE OUT THESE TWO BUNDLES FROM SEA ON 24. MARCH 2013 BETWEEN AT 0930 AND 1130 HRS LT BUT RESULT WAS UNSUCCESSFUL. WE NOTED NO PROTECTION NET BEEN USED BETWEEN THE SHIP SIDE AND THE PIER.

UNDER THE CIRCUMSTANCE, I PROTEST AGAINST DAMAGES/SHORTAGE AND I HOLD THE STEVEDORE COMPANY FULLY RESPONSIBLE FOR THE SAID DAMAGE, AND FOR ALL CONSEQUENCES WHICH MAY ARISEN THERE FROM.

PLEASE KINDLY INFORM CONCERNED PARTIES ACCORDINGLY.

YOURS FAITHFULLY

MASTER OF M/V ATLANTIK PRIDE
ÜMIT TURAN ŞAHİN

[Signature]

IMO 8313336
MONROVIA

252
To Whom it may concern

Data Collection Visits

This is to certify that Mr. Safaa Abdulhussein Alfayyadh, a citizen of Iraq, has been visiting Umm Qasr Port several times as listed below for the purpose of data collection to fulfill the requirement of his research “Development of the Framework for a Lean, Energy Efficient and Environmentally Friendly Port: Umm Qasr Port as a Case Study”. He is given a permission to access and use the port data for analyzing this data for academic purposes only. As researcher, Mr. Safaa was participating and witnessing the port operations in details in order for him to collect first hand data as he planned his research methodology to be carried out in this method of identifying non-value adding processes. Furthermore, he was conducting interviews with port management, operation management, employees and port customers.

Schedule of visits:
1- 10-13 March, 2014  
2- 5-9 July, 2014  
3- 9-12 December, 2014  
4- 15-17 March, 2015  
5- 6-8 June, 2015  
6- 28-30 July, 2015  
7- 18-21 October, 2015

We would like to take this opportunity to express our concerns of gaining benefits out of the outcomes this research project hoping that this organizational investment is successful.

If you should have any questions please contact port management by email.

usp@scp.gov.iq

Sincerely,

Haitham Kadhim ALJAZAERI
Acting Port Manager

Salah ALTAMEMY
Administration Manager