**UNIVERSITY OF KWAZULU-NATAL**

# A Lean approach to enhance operational efficiency at the Bulk and Break-Bulk Terminals at the Port of Durban

**By**

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## ABSTRACT

The purpose of this research was to explore the approach of the lean concept to enhance operational efficiency within the bulk and break-bulk terminals at the Port of Durban. The methodology used in this study included quantitative and qualitative analysis of secondary data obtained from the organizations Management Information System's department and data collected from direct operational observations on the bulk and break-bulk terminals material handling process. Data collected from direct observations were used to create a Business Process Map (BPM) and activity process chart to establish cycle times per activity for the bulk manganese operation. Through the use of literature and the research methods adopted, the current overall operational performance of the bulk and break-bulk terminals at the Port of Durban was determined as well as the operational performance of the bulk manganese material handling process. Key performance measurements established whether the current performances achieved the design targets and the limitations in achieving operational performances were also established. From the findings, a lean framework was recommended to support the enhanced material handling flow of bulk and break-bulk cargo within the terminals facilities. This study makes a contribution in many ways. It analysed and establishes overall port performance and bulk manganese operational performance in line with key performance measures, business process mapping and process activity tools were used to identify wastes, non-value adding activities and establish standard cycle times per activity. The total population size was 80 observations per element of which the sample size was computed to be 64. The results from the study reveal that the overall port performance of the vessel turnaround time was underachieved by 91,6% of the target, the truck turnaround time achieved and exceeded the target by 5,7%, the ship working hour rate underachieved the target by 8,7% and the cargo dwell time underachieved the target by 54,2%. It was further determined that operational delays of 9,97 hours contributed to the poor performance. Some of the delays observed attribute to time lost in waiting for equipment (15%), waiting for rail wagons to be shunted inn (47,7%) and placed at the operation area (16,7%), wasted time in shift change over and labour taking longer breaks (11,4%), insufficient stockpile capacity (9,2%). The implementation of a lean framework was recommended to mitigate challenges and improve the operational efficiency.

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# ABBREVIATIONS

| | |
|---|---|
| BCT | Bulk Cargo Terminal |
| BPM | Business Process Map |
| DEA | Data Envelopment Analysis |
| FIFO | First-in First-out |
| GCOS | General Cargo Operating System |
| HHC | Half Height Containers |
| ICT | Information & Communication Technology |
| JIT | Just-in-time |
| KPI | Key Performance Indicator |
| LPT | Lean Production Theory |
| MIS | Management Information System |
| MPT | Multi-purpose Terminal |
| OECD | Organization for Economic Cooperation and Development |
| PDCA | Plan-Do-Check-Act |
| RoRo | Roll on Roll off |
| RTT | Rail Turnaround Time |
| SWH | Ship Working Hours |
| TCR | Trans-China Railroad |
| TNPA | Transnet National Port Authority |
| TSR | Trans-Siberian Railway |
| TPH | Tons per Hour |
| TPM | Total Productive Maintenance |
| TPS | Total Production System |
| TPS | Toyota Production System |

| | |
|---|---|
| TPT | Transnet Port Terminals |
| TQM | Total Quality Management |
| TQPMS | Total Quality Port Management System |
| TTT | Truck Turnaround Time |
| TVCC | Transnet Value Chain Coordination |
| UKZN | University of KwaZulu-Natal |
| UCTD | United Nations Conference on Trade and Development |
| VSM | Value Stream Map |
| VTAT | Vessel Turnaround Time |
| WIP | Work in Progress |
| YTD | Year to Date |

# CHAPTER ONE

# INTRODUCTION

## 1.1 Introduction

Seaports have a great impact on the economy of the country (Langen & Nijdam, 2012). 90% of the global trade is facilitated through seaports (IMO, 2012). South Africa’s ports contribute 3, 5% of the global seaport trade and 98% of the country’s goods are transported by sea (Chasomeris, 2006). South African ports are seen as the gateway to the Sub-Saharan African region. A fundamental aspect of the operational activities that occur in a port is the movement of cargo from one mode of transport to another, this phenomenon is known as terminal operations (Olesen, Popovska & Hvolby, 2013). South Africa has eight commercial ports that are state-owned and managed by Transnet National Ports Authority (TNPA) (Gumede & Chasomeris, 2015). South Africa’s Ports are separated into container terminals and bulk and break-bulk terminals; 37% of South Africa’s bulk cargo and 78% of the break-bulk cargo is handled by Transnet Port Terminals (TPT) compared to the private sector (Gumede & Chasomeris, 2015). Bulk and break-bulk terminal’s facilities and complex activities are seen as adding value in port supply chains (Rodrigue, Comtois & Slack, 2013). The growth in global trade and the globalisation of markets has developed extreme competition amongst ports (IMO, 2012). This extreme competition has resulted in organizations focusing more on enhancing the efficiency of their ports. Marlow & Paixao (2003) propose that ports need to apply a lean approach through lean principles and philosophies in order to cope with new trends in enhancing operational efficiencies within the port environment. The purpose of this dissertation is a lean approach to enhance operational efficiency at the bulk and break-bulk terminals at the Port of Durban.

This chapter seeks to provide an introduction to the study conducted, the motivation and focus of the study, the problem statement and the objectives of the study.

## 1.2 Motivation for the Study

As organisations find it difficult to stay profitable during times of economic downturn, many organizations have embraced process improvement techniques as an approach to improve competitiveness. A lean approach in operations, has been applied over the past years by numerous organisations with an aim to improve efficiency and productivity (Worley & Doolen, 2006). According to Hines, Holweg & Rich (2004), lean port operations will improve quality and efficiency and become a continuous pursuit to reduce costs and waste within the operational process and benefits are realized in the processes and outputs of the operation. Port efficiency studies of Sub-Saharan Africa and other African seaports have been approached from different perspectives by different researchers. Raballand et al. (2012) and Refas and Cantens (2011) are amongst the relatively few studies that have an economic perspective which empirically demonstrate that the high dwell time of cargo, which negatively impacts on port efficiency, could be the result of factors other than transport infrastructure inadequacies, as has been previously held. Indeed, other port researchers have discussed port efficiency of non-Sub-Saharan Africa ports from different perspectives Ports create employment for people in the port region and indirectly create social development especially for small to medium enterprises through the economic activities it attracts (Worley & Doolen, 2006). Poor performing ports waste resources and capital which results in a lost opportunity for the country to benefit from the trade it attracts. In order to create value for the economic hinterland, it is essential for a port to function to optimal efficiency. Improving the operational efficiency and effectiveness of the bulk and break-bulk terminals not only assists the profitability of the facilities but also has flow-on benefits for the organizations internal stakeholders, external stakeholders such as customers, shipping industries, ship agencies, other operating divisions and the port's environment.

## 1.3 Focus of the Study

The study's key area of focus is on the operational activities as this is where the key operational performance is measured at the bulk and break-bulk terminals at the Port of Durban. Previous studies have found deviation from norm. The study firstly looks at the overall operational performance of the terminal for seven months from April to October 2017 of the 2017/2018 financial year and then focuses on the material handling processes, specifically of bulk manganese. The study also seeks to enhance the terminal's operational efficiency by applying lean philosophies to identify and eliminate waste and non-value adding activities.

## 1.4 Problem Statement

The growing cost and competition of seaports, the unpredictable demand of customers and the efficient use of limited land amongst others, results in the need for the port to operate efficiently. It is of fundamental importance that a seaport functions optimally and efficiently to generate value for the economic region it services. An approach used to achieve enhanced port performance through the elimination of waste and the improvement of performance efficiencies, is the concept of lean. Ports that underperform, misuse resources and do not capitalise on opportunities for the hinterland to benefit from the business that can be attracted (De Langen, 2004). Positioned at the interface of waterside and land transportation, South African Ports are the main access for international trade in the Sub-Saharan African region. 90% of the volume of cargo that is exported and imported in the Sub-Saharan region uses ocean transport as a mode of transportation (Raballand, Refas, Beuran & Isik, 2012). Although there has been recent transformations and investments made to grow volumes in bulk and break-bulk terminals, several ports in the Sub-Saharan region are the most unproductive globally when compared to worldwide standards (USITC, 2009). Bulk and break-bulk ports are at a disadvantage as they lack adequate facilities and capital which contribute to long delays and operational turnaround times, high dwell times cause port congestion which have an influence on high transport costs, export competitiveness and import rates. In order to enhance the operational opportunities to ensure expansion and to remain competitive within the bulk and break-bulk environment at the port industry, it is essential to analyse the key operational performances. Accordingly, this paper aims to analyse the operational efficiency of the bulk and break-bulk terminals at the Port of Durban which is important if the Port of Durban wishes to sustain its dominant position in Africa.

## 1.5 Objectives

The overall purpose of this study is a lean approach to enhance operational efficiency in the bulk and break-bulk terminals at the Port of Durban.

In order to achieve the overall purpose, the specific objectives of this study are as follows:

1. To examine from literature on the lean principles that can be implemented to improve efficiency in a bulk and break-bulk environment

2. To analyse the current overall operational performance levels at the bulk and break-bulk terminals at the Port of Durban

3. To study the material handling operations of bulk manganese through direct operational observations at the bulk and break-bulk terminals at the Port of Durban

## 1.6 Methodology

The research objectives will be addressed by (i) analysing the data on operational performance reports that are already available at TPT's Management Information System's department (MIS). This is a secondary source of information that contains data regarding the overall key performance operation measurements at the bulk and break-bulk terminals at the Port of Durban. The reports analysed, contain data from April to October 2017. Quantitative analysis was used to determine whether the current operational performance achieved the design targets. (ii) Analysing data on bulk manganese material handling operation performance reports through first-hand operational observations conducted by the organizations continuous improvement (CI) department. Direct observations were conducted over ten vessels and an activity sample of 64 observations were conducted on the rail operations. The data collected from the observations were used to compile the performance reports. Quantitative data analysis determined whether the current operational performance achieved the design targets. Business Process Maps and activity process charts for the bulk manganese operation were established and operational delays were analysed to determine whether the performance of the operation was efficient.

## 1.7 Chapter outline

The study will progress according to the following chapter outline:

- Chapter one provides the introduction to the study, the motivation for the study, the focus area of the study, the problem statement, the objective of the study and a high level overview of the research methodology used to conduct the study.
- Chapter two reviews the literature behind lean philosophy and lean principles in a seaport context and discusses operational performance measurements at a bulk and break-bulk port environment.
- Chapter three discusses the research methodology, research designs and paradigms used to conduct the study as well as the aim and objective of the study. The study setting and sampling technique used is discussed and the construction of the data collection instrument is explained. Reliability and validity of the data and ethical considerations are also discussed.
- Chapter four presents the results from data collected and analysed as well as limitations that hinder the required operational performance. The chapter concludes with a discussion of the results.
- Chapter five concludes the study and provides recommendations to be implemented. Limitations of the research conducted and recommendations for future research are also discussed.

## 1.8 Summary

This chapter provided a high-level overview of the study conducted, indicating the need and focus area of the study, the problem statement, the purpose of the study, the research methodology used and the outline of the proceeding chapters of this study.

The proceeding chapter is a literature review providing thorough understanding of lean philosophy, lean principles and operational performance measurements within a bulk and break-bulk terminal environment.

# CHAPTER TWO

# LITERATURE REVIEW

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## 2.1 Introduction

The majority of practises around lean philosophy is initiated with an assumption that there is a theoretic ‘ideal state’ for every organisational business process and that the existing state does not conform to the ‘ideal state’ due to inefficiencies and waste (Shaked, 2017). The purpose of this chapter is to conduct a theoretical evaluation of existing literature regarding a lean approach to enhance operational efficiencies in the port sector, focusing on bulk and break-bulk. This chapter will form a basis of knowledge to support fundamental arguments and assumptions of conventional theory and give a thorough understanding of the origin of lean, what lean philosophy is, and developments of lean thinking in the direction of how it can be implemented in the bulk and break-bulk sector of ports. The various operating divisions within Transnet that are interrelated in achieving port performance are Transnet Freight Rail (TFR), Transnet National Ports Authority (TNPA) and Transnet Port Terminals (TPT). An overview of the seaport industry is highlighted, encompassing leanness and efficiencies within the port environment. The literature review then goes on to explain some of the key performance indicators that forms part of the measurement to monitor and control efficiencies at the port.

## 2.2 Lean Philosophy

According to the Institute of Lean Enterprise (2000), Henry Ford was the primary person recognized with introducing lean management practices on a large scale within organizations. He structured the production process of the Model T vehicle by positioning resources such as components, labour, equipment and tools in a continuous system. The problem with Ford’s lean approach is that it was not adequately well-matched for complex work environments and was well suited to operate in a “straitjacket” production environment. The origination and fundamentals of “lean thinking” was a concept that was first used in the Toyota Production System (TPS) developed by Kiichiro Toyoda together with other individuals that worked at

Toyota in 1930 and in 1990 was propagated by Womack and Jones (1996). The lean practice was first developed in the manufacturing sector after World War II and was introduced by Taiichi Ohno and his acquaintances whilst working with the Toyota motor company (Clegg, Pepper and Spedding, 2010). These visionaries that worked at Toyota achieved the concept of “manufacture to order” instead of “manufacturing to fill the warehouse” (Shaked, 2017). They realised that products should be supplied based on demand as it made financial sense to base production volumes on actual sales. Production volumes based on actual sales was then named Just-in-time (JIT).

According to Liker (2004), the fundamental notion behind the lean philosophy is the elimination of waste. The Japanese refer to the lean concept as Muda which focuses on improving all factors in a production system or operational process and creating value added benefits for the customer (Ohno, 1988). Lean philosophy encompasses an overall system efficiency, continuous improvement, value-added activity benefits and respect for individuals.

According to Womack and Jones (1996), Toyota’s physical production line has two vital lean models: (1) A Pull system – only components that are required are made, regarding demand and supply. (2) Jidoka - when a mistake occurs on the production line, the automatic machines will stop operating. Lean philosophies aim at decreasing production or operational variability by focusing on streamlining production or operational flow of material throughout the entire organization.

According to Womack & Jones (1990), lean recognizes seven main forms of waste which are non-value added activities in a production system or operational process in the entire organization, specifically: transport, inventory, unnecessary movement, waiting (time on hand), over-processing, overproduction and defects. Waste was also defined by Senaratne & Wijesiri (2008) as surplus materials, delays, rework and defects. Hosseini et al. (2012) indicated that Formoso et al. (2002) suggested an extensive classification of waste which does not only include material waste, but also includes waste produced in operational environments such as transportation times, waiting times and setup time.

### 2.2.1 Transport waste

Transportation is the movement of goods or material from one location to another, which includes documents, people and material that does not add value to the finished product or service (Senaratne & Wijesiri, 2008). Facilities layout in an operational environment needs to be planned out well and be close together in order to have the optimal movement required for transportation of material, people and documentation which will result in eradicating unnecessary transportation. According to Hosseini et al. (2012), the waste of transport involves material handling equipment, labour to operate equipment, training, safety provisions and additional space for moving the material which incurs excessive amounts of money. This all leads to added cost and lengthy lead times, resulting in delivery complications and unhappy customers.

### 2.2.2 Inventory waste

According to Capital (2004), inventory waste comprises stock and work in process that is in excess of the prerequisite needed to manufacture products or services "JIT". Continuous flow in production will not be achieved when there is a build-up of excessive inventory, prior or post operations. Excess in inventory is a result of unbalanced work flows in operations, failure to use the first-in first-out (FIFO) method therefore having stationary material, incapable processes, not adhering to procedures and lengthy change over times (Rawabdeh, 2005). Every item of inventory has a direct and indirect costs connected to it and money is tied up in that piece of inventory which can be used elsewhere in the organization. Apart from the high costs, the waste of inventory can incur longer lead times resulting in a loss of business due to dissatisfied customers.

### 2.2.3 Unnecessary movement

Waste of unnecessary motion is the movement of labour and or equipment that does not add any value to the final product or service (Rawabdeh, 2005). Only a procedure of transforming the product to the desired state of the customer's requirement adds value to the final product or service. Wasteful movement is as a result of poor workstation arrangement, bulky batch sizes, reorganising of materials, poor workplace design, unnecessary walking and reaching, poor technique design in transferring tools or material from one hand to another hand (Capital, 2004). When employees spend more time searching for components or material rather than performing the actual operational activity, work efficiency and productivity will decrease and this will become noticeable and equipment that are not for unnecessary movement will breakdown due to added wear and tear.

### 2.2.4 Waiting waste

Waste in waiting is the idle time in the operational system created as a result of waiting for material, people, documents and a previous process to complete (Hosseini et al., 2012). Idle time is non-value adding and is a result of two or more interdependent processes not synchronized completely. Waiting time arises due to time needed to conduct rework, unreliable and unbalanced process quality, poor resource coordination, lack of information and lengthy operational changeovers (Capital, 2004). Costs are incurred for the time spent by employees not adding value to the product/service due to waiting and customers are not willing to pay for which knocks profits off the bottom line.

### 2.2.5 Over-processing waste

Waste in over-processing is adding more value to a product or service than the customer requires, when items are produced in larger volumes than required due to a lack of understanding the accurate requirements of customer, the inadequacy to convey the accurate customer requirements to employees and non-conformance of products or processes to customer requirements (Capital, 2004). Examples of over-processing are creating services or processes that are not necessary, elaborate, detailed and lengthy reports, incorrect specifications of products produced that are not what the customer required and no standardisation of best techniques. Resources used to perform the unnecessary additional work costs money as well, over-processing reduces productivity and efficiency as the resources could be used to perform value adding activities that the customer is willing to pay for.

### 2.2.6 Overproduction waste

Overproduction waste is producing products before they are actually required and are produce in huge volumes at a rapid rate resulting in excessive inventory (Rawabdeh, 2005). This type of waste is the worst of all wastes as it obscures the need for improvement and contributes to other wastes. Ideally products should be produced to customer requirements, when they require it, pulling only what is ordered through the production flow. Overproduction is a result of a lack of inaccurate information, producing to forecast and not to demand, unstable and unreliable processes and production schedules, unbalanced supply and demand (Capital, 2004). Overproducing incurs holding cost in the product produced which incorporates costs associated with storage space, resources such as equipment and labour.

### 2.2.7 Defect waste

Activities in any process should be performed accurately the first time in an ideal state, getting it right the first time prevents scrap and rework **(**Capital, 2004). A defect occurs when a product or service differs from the specifications or requirement of the customer, which may be as a result of incorrect or unfinished work sent to the following phase in the process or the end product to the customer. The waste of defects can be avoided by understanding the customer's description of the product or service quality they require. Defects are caused by inadequate training of labour as a result of skills shortage, incapable processes and suppliers of material, excessive stock and transportation. There are excessive costs involved in the waste of defects from rework, setups, unnecessary transportation, administration, material and components, increased lead times, failure to deliver products or services on time and eventually a loss of unhappy customers taking their business elsewhere.

## 2.3 Principles of Lean

As described previously the fundamental notion around lean theory is the elimination of waste in a production or operational process, resulting in permanent improvement in all facets of the organization as well as value creation for the customer. In enabling operational efficiency, the organization creates a competitive consumer focus value proposition environment for the customer. Lean principles are specific to the type of industry implementing it and the appropriate principles and tools need to be identified accordingly to be implemented in the specific industry sector. Lean theory has expanded over the years with research on knowledge of the philosophies and the tools used by organizations through adoption and innovation. An example of this described by Salah, Rahim & Carretero (2010) is the launch of the Six-sigma concept by Motorola in the mid-nineties. According to Mayor (2003), Six Sigma incorporates the methodology of problem solving and applies process optimization and cultural transformation. The application of Six Sigma decreases the quantity of defective products/services, resulting in improved revenue and customer satisfaction which is accomplished by applying a widespread of uncompromising statistical and advanced mathematical tools. Organizations use a combination of lean theory and six-sigma strategies due to their similarity in theory (Mayor, 2003). Lean principles are relevant in the port environment and require experience, knowledge and understanding of implementing lean tools.

Womack & Jones (1996), recognised the following five principles for reducing waste and creating an organization based on lean theory.

1. Identify value for precise product/service
2. Classify the value stream for each product/service
3. Create the value flow with efficiency
4. Allow the customer to pull value from the producer (Respond to customer demand)
5. Monitor perfection through continuous improvement (Kaizen)

These principles form the foundation and sets the tone for differentiation from the rest of the competitors and the manner in which the organization satisfies its customers' anticipations and requirements. Each of the five principles are discussed further below:

### 2.3.1 Identify value for precise product/service and classify the value stream for each product/service:

In order to identify waste in a production or operational process, the value of the product and service must be determined by looking at the product and service from the customer or end-users point of view. A benefit or value proposition for the product and service is established which evidently describes the value or benefit that the customer will acquire upon use. According to Hines & Rich (1997), the ultimate goal is to produce products that are exactly what the customer ordered without waste. The subsequent phase is to identify the value obtainable from the product and service through a value stream map (VSM) at any interval within the operational process. VSM serves as a tool and can be used in several ways to identify the relevant waste in the process. VSM is a lean tool or lean approach technique used to analyse, document and ultimately improve the activity of the flow of material and information necessary to yield a service or product for an end-user (Hines & Rich, 1997). The VSM methodology is specifically supportive with the aim of reducing the cycle time within an operation.

By classifying the value stream for every product/service, the ultimate objective is to establish if the activities or elements within the process creates value or not (Monden, 2011).
Monden (2011), defines three types of activities/elements:

1. Value adding;
2. Necessary but non-value adding;
3. Non-value adding.

A value adding activity requires the operational process to be streamlined and adjusted to remove any form of waste such as waiting time or unnecessary movement. The element of necessary but non-value adding is accepted as it forms part of the existing operational process conditions and is difficult to eliminate.

### 2.3.2 Create the value flow with efficiency

The aim of this phase is to reduce the lead time by ensuring that there is no waiting time or idle time in the production or operational process. Barriers to the flow of value need to be eliminated. The word flow is referring to the ease and swiftness of materials “movements” through the operational process. Barriers for example can be bottlenecks in the process, large consignments of inventory, unnecessary meetings, awaiting approvals, etc. in the midst of the operational process. According to Mi Dahlgaard-Park, Dahlgaard, & Mi Dahlgaard-Park (2006), organizations that have a mass-production business model, are dependent on large consignment type production including the waste accompanying it. Once these barriers have been removed, the organizations’ production processes will be prompted by actual market demand and will be permitted to consent their customers to "pull" value.

Sugimori, Kusunoki, Cho, & Uchikawa (1977), states that the most essential lean tool to create flow is JIT, and defines the fundamentals of this tool as only the required product or service at the required time in the required volumes. JIT requires variability to be eliminated; variability such as product, demand and task of employees. By decreasing variability, the workforce is forced to work competently and plan proactively.

### 2.3.3 Allow the customer to pull value from the producer

Pull value is a concept that is associated with value creation in a product or service as near as the product or service is required by the customer. Waste associated with unnecessary motion and movement, excess inventory and unnecessary transport can be eliminated by implementing a value creation on-demand approach. The organizations customer service and the engineering department play an important role in this phase and pull value is largely dependent on these departments. It is vital for an organization to know precisely what the customer’s requirement is in order to avoid waste. Having a close relationship with the organizations purchasers can help to know the exact requirements of the end user and the information about actual demand flows from the bottom up.

### 2.3.4 Monitor perfection through continuous improvement (Kaizen)

Upon application of the above phases to an organizations operational processes, it is apparent that there is no end to eliminating waste prospects. In order to attain the best quality and success through value creation, all employees within the organization need to make every effort to ensure continuous improvement.

A lean tool known as total quality management (TQM) has been used over the years in organizations as a technique for continuous improvement and quality management to apply lean theory. According to Dean & Bowen (1994), TQM is a management approach that is categorised by the philosophies, practices and methods focusing on continuous improvement, customer centricity and team collaboration.

Areas of improvement on application of lean comprise of strategic advancement such as reducing costs, administration improvements such as decreasing the number of processing errors and operational improvements such as better productivity, reduced work in progress (WIP) and lead times. Andersson et al. (2006) describes some of the benefits of lean; increasing the number of times inventory turns, reducing the cycle time of an activity and the (WIP), improving consumer satisfaction rates and the efficient utilization of available capacity. El-Haik & Roy (2005), states that the mainstream measures of the lean concept in an operational or service type environment will focus mainly on achieving reduced costs, better speed and agility, improved quality, greater effectiveness and efficiency. Mason et al. (2014) describes lean as an improvement technique which results in serving a purpose of the elimination of waste by focussing on planning and fine-tuning operational activities to maintain the phases of the process. The lean concept focuses on eliminating sources of waste. Hines et al. (2004), outlines the advancement of lean philosophy that consists of value streams and value systems, the shop floor, cells and assembly lines. Lean tools are used to enhance an organizations operational activities. Figure 2.1 as a House of Lean model, illustrates the standard and specialised lean tools (Myerson, 2012). The standard lean tools are: visual place of work, visual work aids, standardized work and 5S (sort, sweep, set in order). The specialized lean tools comprise of Kanban, TQM, Total Productive Maintenance (TPM), Kaizen and quick changeover teams. Kanban is a method of improving operational and production services through visual instructions received to carry out the next activity within a process (Anderson, 2010). A VSM as mentioned earlier is a lean philosophy application that is used to reduce and eliminate waste.

The standard and specialised lean tools are illustrated below in figure 2.1 as a House of Lean model:

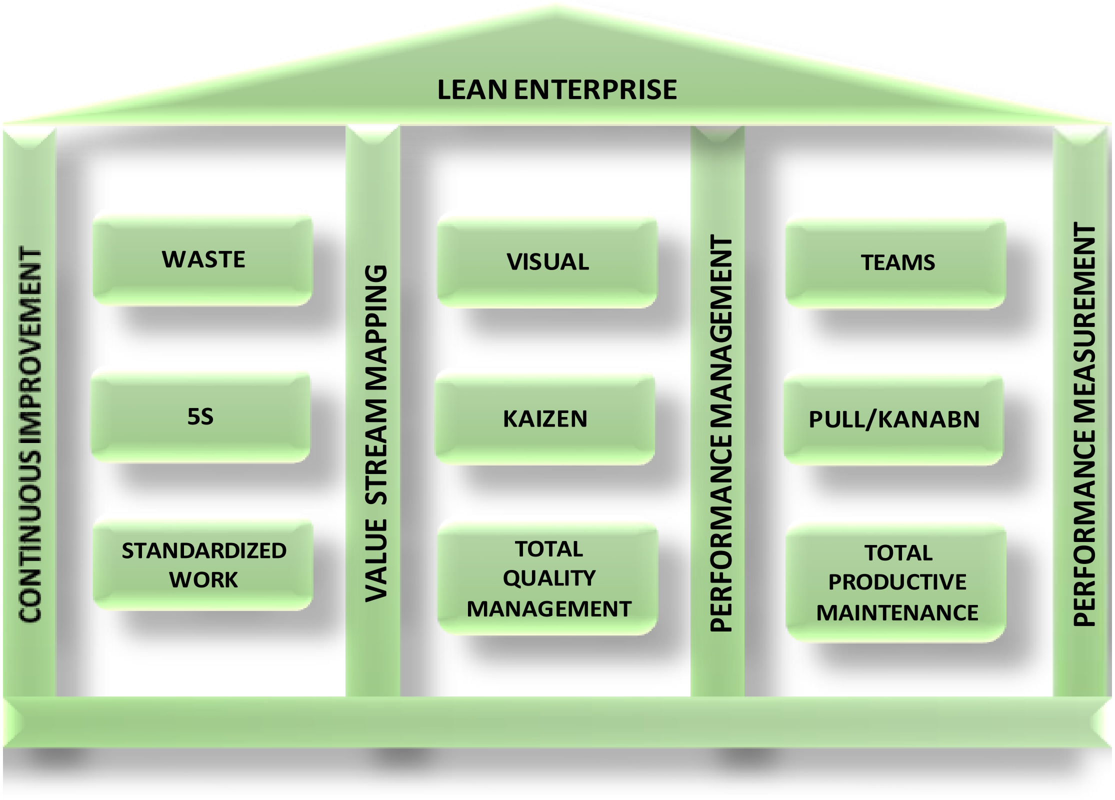


Figure 2.1: House of Lean model

Source: Adapted from Myerson (2012, p97)

One of the main focus areas of the lean concept is creating value for the end-user or customer. Hines et al. (2004) validates the association between value creation for the end-user and the cost of the value creation in detail. The cost-value relationship demonstrates the cost-benefit status of the product or service for which the end-user is willing to pay for the cost of the product or service. Value is produced for the end-user when waste is reduced or eliminated resulting from a decrease in waste in internal processes and the introduction of added features or services. Non-value added elements can be eliminated, resulting in efficient processes. Variations in processes and how processes work need to be understood (Lighter, 2014).

## 2.4 A Lean Framework for enhanced operational efficiency

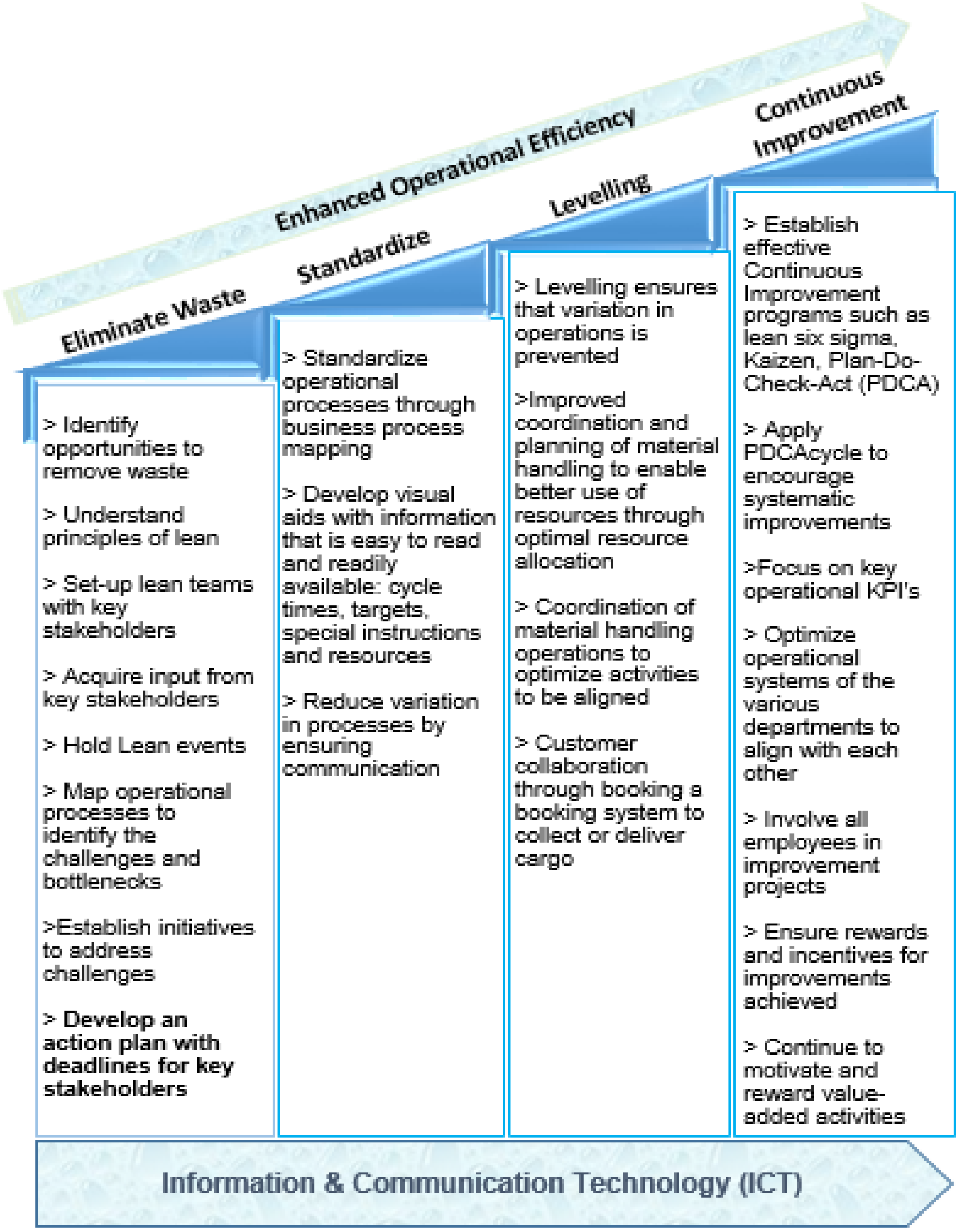


Figure 2.2 Lean implementation framework

Source: Adapted from Powell, Hvolby & Fraser (2015, p. 276)

The lean framework comprises of 4 essential philosophies as illustrated in figure 2.2, that can be implemented to support the enhanced material handling flow of bulk and break-bulk cargo within the terminals facilities: (1) eliminate waste, (2) standardize, (3) levelling and (4) continuous improvement. The lean framework requires ICT to support the implementation of the entire framework in providing information of integrity and effective communication networks. According to Olesen et al. (2013), ports are usually focused on incremental improvements, working towards a more integrated systems approach which is supported by ICT.

### 2.4.1 Waste Elimination

According to Ohno (1988), the implementation of the elimination of waste is used to enhance operating efficiencies by a large amount. Unnecessary transport of bulk cargo and movement of equipment within the terminal can be reduced significantly by planning stockpiles closer to vessel berths and rail lines in the bulk and break-bulk terminals at the Port of Durban. Time wasted in waiting can be reduced through effective planning and optimal resource allocation, equipment breakdowns can be eliminated through preventative maintenance, shift changeover delays and lengthy lunch breaks can be eliminated through staggered breaks. Eliminating waste can be done through planning lean events which entails the gathering of the terminals key stakeholders or specialists in their fields to gather information on the processes, the operational processes are then mapped and bottlenecks within the processes are identified, initiatives are then established to address the bottlenecks and key stakeholders drive the actions to be implemented.

### 2.4.2 Standardize

Standardization results in stable processes by eradicating variability and inadequate standardization produces waste within a process (Ohno, 1988). In order to reduce and remove variation within the material handling process at the terminal, it is operational processes need to be standardized through business process mapping and conducting time studies which will result in achieving the activities cycle times within the process. Standardization is applied in lean operations to encourage a continuous improvement culture and reduce variation in processes (Shingo, 1989).

#### 2.4.3 Levelling (Heijunka)

Levelling is applied in lean operations within the port environment to address the variability in the flow of cargo and to have a coordinated operational process. Variability in operational processes results in an uneven work flow such as the loading and unloading of vessels and trains and at times may even have an unbalanced work load on labour. Implementation of levelling within operations in the terminals create a more balanced working schedule and make optimal use of the terminal capacity to plan stockpiles according to the work-load and demand of capacity required. This will result in decreasing cargo dwell times as a synchronized throughput of cargo through the terminal will contribute to improved dwell times.

#### 2.4.4 Continuous Improvement

The last component of the framework, is continuous improvement. Continuous improvement also known as Kaizen has been practiced successfully at various organizations to motivate labour to participate, commit and adopt a culture of continuous improvement in their day-to-day activities. The application of Plan-Do-Check-Act (PDCA) cycle supports systematic improvements of the bulk and break-bulk terminals operations. Tools such as business process mapping, value stream mapping and root cause analysis can be applied in contributing to improved value-adding activities.

## 2.5 Overview of the Seaport Industry

The seaport industry plays a vital role in today's global business allowing a gateway to other countries and other regions within the country for trade. A seaport's function is to provide access and services for vessels that enter the country's waters. Sea operations encapsulate various specialized trades such as freight transport in bulk and break-bulk products, containers, liquid bulk such as fuel and oils, passenger vessels such as transporting people and the building of ships. According to Rodrigue et al. (2006), there are three main corridors in seaport logistics i.e.: waterside access, waterside interface and landside access. Waterside access refers to the berth capacity of vessels and the infrastructure to accommodate and service vessel operations. Waterside interface is the crossing point between the ocean and land which indicates availability of space to support waterside access. Landside access is the infrastructure that provides a service from the port to industrial organizations, warehouses and industry hubs.

According to Panayides & Song (2013), maritime logistics consists of the preparation, executing and organising processes of the logistics of cargo and information in sea transport.
Furthermore, there are three key activities associated with maritime logistics: freight forwarding, port operations and shipping.

- Freight forwarding mainly consists of documentation and is triggered by reserving space on a vessel for the shipper through planning, documentation for customs clearance, insurance, bill of lading, and so forth.
- Port operations is the actual activity that takes place at the ocean terminals. Activities include loading/discharging cargo into or from vessels and planning the cargo through inland transport to be delivered to the customer. Terminal activities can include value added services such as material handling, storage, warehousing, packaging and planning the inland transportation to customers.
- Shipping which are the activities involved in the transfer of cargo from one terminal/port to another and provides services that effectively support the maritime logistics network flow such as tracking of cargo, notifications, and so forth.

Transnet port terminals has introduced Transnet Value Chain Coordination (TVCC) which utilises the different forms of intermodal transportation such as inland rail (vessel to rail or rail to vessel), inland road transport (vessel to road or road to vessel) and short ocean freights for all cargo logistics through the Transnet infrastructure and customer logistics network. TVCC is managed through the coordination of operational activities between Transnet’s operating divisions such as Transnet Freight Rail and Transnet National Ports Authority.

Alderton (2008), states that the additional value-added benefits offered by ports/terminals puts them in a strategic position which results in a competitive edge amongst competitors in the logistics value chain. Apart from the cargo having value-added benefits, it also contributes to increasing the profitability of the terminal and apart from the conventional stack, stockpile and storage facilities provided, the port can offer further services such as distribution centres.

### 2.5.1 Types of Terminals

Ligteringen and Velsink (2012) state that there are various types of terminals , i.e.: Multi-purpose terminals (MPT), Bulk cargo terminals, General cargo terminals, Roll on Roll off (Ro-Ro) terminals, Container terminals, Liquid Bulk terminals, Fruit terminals and Passenger terminals that are defined as follows:

- MPT: handle a mix of cargo, hence the name multi-purpose and provides a more flexible cargo handling operation. The terminal has material handling equipment of a diverse range to load/discharge commodities such as containers, general cargo, bulk cargo and steel/project cargo.

- Bulk Cargo terminal (BCT): are equipped and built to handle, stockpile and warehouse bulk minerals mainly in its natural state such as coal, iron ore, fertilizer, grain, wheat, woodchip, etc. Commodities handled at bulk terminals are loaded by conveyor belts which run above the vessel to allow the cargo to travel from the storage area to hatches on the vessel at a constant and high capacity for export. For imports, the cargo is discharged by the vessels crane and placed onto equipment on the landside which transports the cargo to storage areas within the terminal, directly to the customer by road vehicles or direct to inland customers by rail.

- Ro-Ro terminals: handle all rolling cargo such as vehicles and abnormal cargo. The terminal has adequate capacity to stack vehicles and diverse terminal layouts for vehicle parking required.

- Fruit Terminals: are equipped with refrigerated facilities such as reefer containers to handle and store fresh produce which are placed close to the waterside. Cargo is sometimes moved straight to the vessel instead of being stored due to the life span of the fresh produce.

- Liquid Bulk terminals: are equipped to handle petroleum products such as oils, fuels, chemicals and liquid gas. These commodities are hazardous cargo and require all safety checks in place.

At the Port of Durban: the MPT terminal is situated at Point, BCT terminal is situated at Maydon Wharf and Agriport and the Ro-Ro and Fruit terminals are situated at Point.

According to Tsinker (1997), the advancement of contemporary ports is interrelated with the entire transport system to enhance the complete system. Some cargo, depending on the customer's agreement, are held in warehouses and storage facilities within terminals that serve as a temporary buffer until the end-user collects; whilst other cargo is delivered directly from the waterside to the customer's premises. According to Van Vianen et al. (2012), these buffers which serve as temporary storage for cargo, results in the speed of deliveries to the end-user and rates of loading/discharging of cargo to be independent of each other.
Bulk cargo as mentioned earlier are in the form of bulk minerals such as iron ore, fertilizer, coal, phosphates and agriproducts such as wheat, maize, grain, woodchip and soya. There are various methods of handling bulk commodities such as sucking (grains, wheat, etc.) and a mixture of grabs and conveyor belt coordination (coal, iron ores, fertilizers, etc.). It is important to take into consideration the contamination of products handled through the same facility or handling method. Contamination can incur major costs for the terminal resulting from incorrect methods being used, decreasing the organizations bottom line. The handling of bulk cargo requires high end technology established at the berths on the waterside due to the complexity of the cargo being handled and storage capacity is always a limited resource within the terminal due to the large volumes handled at a constant rate. The agents that provide material handling equipment and services to the terminals have a service level agreement to support the ports activities and the capacity design of the cargo handling equipment has been planned well.

According to Notteboom (2006), there are different types of capacity levels in a port environment such as design capacity, planned capacity and actual capacity. The design capacity is the scientifically calculated output capacity of the operational process based on theory. The planned capacity is the design capacity minus predetermined elements such as preventative and planned maintenance, housekeeping, training, toolbox talks, set-up times and shift changeover. The actual capacity comprises of the design capacity less predetermined factors and unpredicted activities such as weather delays, machine failures, employee absenteeism, etc. Alderton (2008) defines capacity in bulk terminals as maximum capacity, rated capacity and actual capacity. Maximum capacity is the peak discharge rate under total optimal circumstances, rated capacity is the discharge rate established on the cycle time of the vessel crane or grab from the initial point of discharge on the vessel hatch to the receiving point on the landside alongside the berth and actual capacity is the average hourly rate of discharging the entire cargo from the vessel.

### 2.5.2 Performance of the Port

In order for ports to be more competitive and attract customers, port performance needs to improve on a continuous basis by all stakeholders within the organization. According to Tongzon & Heng (2005), the private segment of the port industry's involvement in the port sector, contributes to improving the efficiency of port operations and this efficiency is important to gain a competitive edge over competitors such as terminal operators and port authorities. This simply means that an effective way for port authorities to gain a competitive edge and be successful is to have fractional port privatization. Management within the organization will be motivated to measure performance at the port in order to determine how effective knowledge and information has been transferred to achieve the required efficiency (Marlow & Casaca, 2003). According to Yeo et al. (2008), modern day ports have moved away from hardware and the workforce to highly automated systems through software and advanced technology which are strategic factors that contribute to the competitiveness of the port industry. According to Paixão & Marlow (2003), agility in the port environment is significant in contributing to competing effectively amongst the competitor environment. The agility in ports prove the position of the port competing in the global environment. Ports compete on a global level and recently the competitiveness of ports have been seen to be increasing over the past few years. Cost has been one of the key differentiators but of recent times, the quality of the service provided has also been seen as a key factor in gaining a competitive advantage (Paixão & Marlow, 2003). Factors that have an impact on the global competitive environment are globalization, the significant evolution of technology advancements, uncertainty of future occurrences especially with economic and commercial aspects and agile electronic systems. According to Caballini et al. (2012), an incorporated organisational style approach should be used for a port rail synergy, both technological and physically structural. This approach is important in enhancing efficiency through the port rail synergy, resulting in cargo transformation from road to rail which makes a significant contribution to the economy.

The competitiveness and desirability of a port becomes a trigger point to meet and exceed customer requirements. Some of the topmost negative port characteristics that customers are dissatisfied with, are unnecessary administrative processes, lengthy turnaround times, port congestions, incorrect completion of cargo damage claims, unclear pricing negotiations, poor customer service and the absence of a customer service index in terms of a monitoring or tracking system in giving feedback on customer complains (Hu & Lee, 2011). The port's key performance indicators typically consist of operational indicators measured through productivity, volumes, operational turnaround times, equipment turnaround times, labour productivity; service indicators which are measured through customer service index, availability of resources, berth utilization and land/storage capacity. Thoresen (2014) mentions that terminals management can reduce the waste of delays caused due to operational waiting time, this can be done through decisions around increasing the number of vessel berths or freeing up the berths at a faster rate by turning around the vessel much quicker; lengthening the operational working hours and improving operational productivity of the material handling process. The quantity of vessel berths for operations are dependent on the amount of budgeted volumes, size and type of the vessel, capacity, availability of infrastructure, etc. Alderton (2008) states that reducing the vessels port stay, i.e.: reducing the vessel turnaround time and decreasing the operational costs by having optimal resources can improve the productivity significantly. Productivity is inversely proportional to turnaround time and cost, meaning that when turnaround times and costs are low, productivity increases. Berth occupancy rate is used to determine how productive a terminal is in servicing a vessel during port stay. Port stay is the actual time a vessel is being serviced and berthed at a terminal which includes deductible delays and non-deductible delays. Dwell time is the time that a cargo spends in the terminal, waiting for the next progressive step and waiting time of a vessel is the time the vessel waits at anchorage for the next available berth to be serviced. When the terminal cannot satisfy the demand of capacity required, the result is port congestion, higher transport costs and dissatisfied customers.

## 2.6 Leanness and Efficiency at Seaports

Seaports have a great impact on the country's economy in the port environment and industry sector and is seen as a gateway to international trade (Langen & Nijdam, 2012). Almost 98% of South Africa's cargo is exported by sea through the various port terminals (Port of Durban… 2016). Bulk and break-bulk constitutes 44% of South Africa's cargo that moves through the Port of Durban's bulk and break-bulk terminals. (Port of Durban… 2016). Ocean ports are a huge contributor to creating employment primarily in the port vicinity and secondarily through the trade and industry activities it draws. Consequently it is imperative that ports generate value added benefits through innovation for the commercial hinterland it services by operating in an efficient and suitable manner conforming to industry requirements. Poor performance of ports as a result of waste of resources is a missed opportunity for the economy to benefit from the trade it can capitalise on. In order to be more competitive in this economically challenged environment, Marlow and Paixao (2001) recommended that seaports need to be more efficient through agility in the way that they conduct business. The competitive environment in terms of growing costs and quality in ports and between ports, the utilization of limited land space and the inconsistent demand of customers apart from other causes result in the requirement for ports to be efficient. Ports are required to follow logistics trends as there is an increased demand for port services. If cargo is not required to pass through the ports due to alternative logistic routes or methods of moving cargo, ports will be at a disadvantage. As in the case of North America, Europe and Euro-Asia; trades using Trans-Siberian railway (TSR) and Trans-China railroad (TCR) (Marlow and

Paixao, 2003). An agile port is a port that is flexible to react rapidly to constant unexpected changes in customer demands with an established structure that empowers the organization to develop and expand in economical markets (Yusuf et al., 1999). Ports need to be efficient and agile as they play an important role in determining the ocean freight rates.

The port industry requires a great amount of capital flow to be in business. There are several additional costs incurred when a port is inefficient such as inventory costs to shippers, increased operational costs to transport operators, and a decreased revenue capability to the port. Since efficient ports have the capability to rapidly adjust and align to processes such as service delivery which are linked to service advancement and production, they are experts in taking on unexpected customer opportunities in the form of new business which permits them to become suppliers of integrated logistics solutions. By implementing an agile and efficient logistics model, ports can improve their flexibility and competency to successfully control the entire logistics chain. For ports to be efficient and agile they need to have adequate infrastructure such as vessel berths, land, roads and railways. In order to meet JIT and lean logistics requirements, port infrastructures should also include traffic management in the form of terminal layouts for ease of access to exit and enter the port and special attention needs to be given to the various requirements of the infrastructure to satisfy trade specifications. Operational efficiency is essential in the port industry due to the competitive environment with elements like productivity, agility, pricing, etc. and the progressive development of the efficiency is dependent on human input such as intellectual knowledge through experience instead of technology and capital in modern logistics (Marlow and Paixao, 2001). Ports are enabled to build strategic associations and partnerships which will assist in enhancing their performance by establishing operational efficiencies through advancing research and propose innovative services to their clients.

Prior to port operations becoming efficient and agile, they need to be lean. Lean production theory is an approach used to accomplish lean ports through the reduction of waste and efficiency improvements. According to Mentzer and Konrad (1991), the main objective of a lean port is to ensure that waste is eliminated within the operational processes whilst transporting freight swiftly and effortlessly to the customer providing an aligned service in accordance to market requirements. According to Suykens (1983), a lean port can only measure what it controls and uses its available resources whether in physical or immaterial state to the best utilization rate by eliminating waste in the tangible and informational processes regarding freight movement and different operational methods within the port. Establishing a lean port by using resources in an efficient manner, will contribute to having minimal costs incurred at all facets within the organization; including funds reserved to construct new ports or refurbish an existing area within the port terminal. Ports are required to work as a network and not operate in isolation in order to be more efficient and successful. Robinson (2002), explains the emergent significance that the port plays within the entire supply chain and further states that the port constitutes a number of supply chains which contends with one and another. Robinson (2002), argues that the role of a port should be examined and serve as a constituent in such a supply chain. According to Marodin & Saurin (2013), the supply chain as an element of examination for lean theory has been thoroughly researched.

## 2.7 Measuring Performance in Lean Ports

A solution to recover from ports inefficiencies such as poor turnaround times, inconsistencies and unreliability, is the advancement of lean seaports and port networks by continuously measuring the ports key performances. When a port's environment is lean, it is easy to recognize the wastes, inefficiencies, flaws and hold-ups as a result of using lean tools and techniques such as VSM. According to Hines et al. (1998), elements of waste in the form of the overall organizational waste within specific value streams are visually identifiable towards eliminating these wastes. Measuring the ports performance is a continuous procedure, as operational processes turn out to be leaner; re-evaluation, adjustments and feedback is necessary in order to contrast actual performance to target port performance. This simply means that when the actual port performance deviates from the target or required performance, corrective measure actions need to be taken and re-evaluated after implementation. According to Marlow & Paixao (2003), the development of the concept known as total quality port management system (TQPMS), the lean concept of JIT and obtaining port accreditation will result from the process of port performance measurement. The process of TQMS is illustrated below in Figure 2.3:

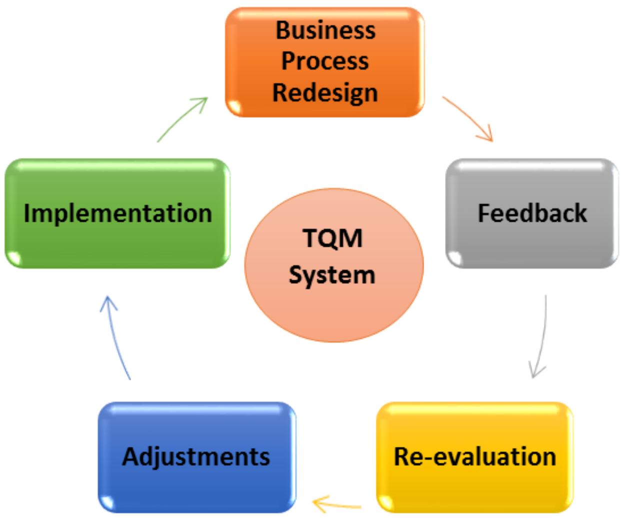


Figure 2.3 Total Quality Port Management System (TQPMS)
Source: Adapted from Marlow & Casaca (2003, p. 194)

The application of Lean Production Theory (LPT) at ports will motivate all stakeholders that are involved in the multimodal port performance measurement processes to contribute greater levels of operations efficiency.

### 2.7.1 Performance measurement at the Interface

In order to develop measurements at the terminals interface, the type of cargo flow needs to be identified. There are 2 types of cargo flow at the terminal, viz. inbound cargo or outbound cargo. Inbound cargo flow, in the existence of a terminal interface is cargo that arrives on a vessel and berths at the interface of waterside and landside to be discharged to storage within the terminal or loaded onto road transport vehicles or rail wagons and dispatched directly to the final destination. Outbound cargo flow is the reverse of inbound cargo flow in that cargo is loaded onto the vessel from storage or directly from rail or road transport and the vessel departs from the terminal interface to the next destination. According to Kallio et al. (2000), the output of these flows or activities require key measurement indicators to be developed which will result in monitoring the efficiency of the various processes. Monitoring these process activities, will enable the measurement technique to be carried out correctly and the targets to be achieved. The ports vessel discharge process measures the efficiency of the discharge process and takes into consideration the effectiveness of the times taken to discharge the vessel from first lift of operations to last lift. The time taken to discharge the cargo results in the cargo handling rate, ship working hours (SWH), vessel turnaround time (VTAT), etc. VTAT is the total operational discharge time from first lift to last lift. Port stay is the total time that the vessel is at the port interface, which is from the time the vessel berths till the time the vessel disembarks. These times are measured from a physical and informational level. The indicators that measure the efficiency of VTAT, SWH, cargo handling rate, cargo dwell time and port stay are measure indicators illustrated from point 1 to 10 under 'Port discharge process' performance indicators' in Table 2.1. Indicators 11 to 14 measure effectiveness of the process activities including sub-process activities.

Table 2.1 Measurement indicators of port efficiency and effectiveness

| Element | Process Activity |
|---|---|
| **Input** | Cargo and transport styles (ships, trucks, trains). |
| | |
| **Output** | Delivery of goods to the hinterland. |
| | |
| **Objective** | Provide a seamless movement of cargo. |
| | Reduce turnaround time of ships, trucks, and trains in port. |
| | |
| **Controls** | Compliance with port policies, procedures and working instructions. |
| | Compliance with international legislation. |
| | Proper handling of dangerous and hazardous goods. |
| | Compliance with customers' requirements. |
| | Points of port congestion, time of the day and delays in minutes. |
| | |
| **Resources** | Human resources. |
| | Information technology/information systems. |
| | Cargo handling equipment i.e., Ship-to-shore cranes, fork-lifts, reach-stackers, straddle carriers, etc. |
| | Quays, berths, storage, silos, warehouse or yard capacity. |
| | Dredged channels and quays. |
| | |
| | 1. Ship's waiting time at anchorage to be berthed. |

| | |
|---|---|
| **Port discharge process' performance indicators** | 2. Berth availability. |
| | 3. Ship's waiting time till first lift to start discharging operations. |
| | 4. Handling rate of discharge operations. |
| | 5. Time waiting for cargo to be transferred from one mode of transport to another. |
| | 6. Time spent: transfer of cargo from storage to next transport mode. |
| | 7. Time spent: value added activities required by customers. |
| | 8. Time for cargo to be cleared (if such is to be done at port level). |
| | 9. Time spent: cargo waiting departure of next mode of transport. |
| | 10. Overall time of cargo in port. (Dwell time). |
| | 11. Annual costs incurred by the port. |
| | 12. Degree of flexibility in using resources. |
| | 13. Degree of process adaptability in meeting customer requirements. |
| | 14. Port costs by unit of cargo handled. |

Source: Adapted from Marlow& Casaca (2003, p. 197)

### 2.7.2. Performance measurement of the Port's Infrastructure

The performance of the ports infrastructure centres on elements in the direct process that has an influence on the smooth flow of rail and road transport operations, dissimilar to other processes that measure the effectiveness of the operation, but also indicates the position of relevant stakeholders. Table 2.2 below, illustrates key measure indicators of effectiveness for road infrastructure within the port environment.

Table 2.2 Measurement indicators of road infrastructure effectiveness

| Element | Process Activity |
|---|---|
| **Input** | Cargo, trucks and/or tractors and trailers. |
| | |
| **Output** | Movement of trucks through road infrastructure. |
| | |
| **Objective** | Provide a seamless movement of cargo. |
| | Reduce turnaround time of trucks (TTT) on roads. |
| | |

| | |
|---|---|
| **Controls** | Condition of road tar/paving/concrete. |
| | Compliance with road construction rules and regulations. |
| | Level of maintenance. |
| | Road traffic flow direction between origin and destination. |
| | Points of congestion, time of the day and delays in minutes. |
| | |
| **Resources** | Human resources |
| | Information technology/information systems |
| | |
| **Road infrastructure process' performance indicators** | 1. Delays caused by road works. |
| | 2. Delays caused by congestion. |
| | 3. Easiness of entry and exit from highways. |
| | 4. Design of road network. |
| | 5. Inter-connectivity of road networks at a national and international level. |

Source: Adapted from Marlow & Casaca. (2003, p. 199)

The port performance system in its entirety allows for the analysis in terms of control and monitoring of the progression of port performance. This simply means that each element or activity of the ports multimodal processes are measured against pre-calculated standards which were determined when specific operational processes were designed. Performance measures are determined on two operational performance levels, which are the external performance levels and internal performance levels and provides the effectiveness and efficiency of controlling and monitoring the terminals operation for all port networks, transport operators and inland terminals. The resulting improvement of controlling and monitoring operations in the advancement of multimodal processes, will put all stakeholders involved under stress to perform at optimal. Logistics operators will be motivated to be competitive regarding the value and quality of the service they provide, given the market demand and not being able to manage with capacity constraints, inland terminals will need to be competitive to improve their services that they provide in order to secure a better place regarding their position and to grow market share. Ports that belong to the network will be driven to improving their operations and conform to implementing lean tools and techniques to achieve a lean port enterprise through their values, beliefs, mission, etc. and eventually the ports within the network will compete with neighbouring ports and international ports at all levels.

According to A la Bititci et al. (1999), every port within the port of networks is identified as an individual operating division or business unit, which works to enhance and advance the services they provide that are market specific, satisfying the requirements of their customers.

For the purpose of this study, the focus will be on bulk and break-bulk terminals and their material handling concepts.

## 2.8 Studies on Operational Performance of Local and International Seaports

According to Bontekoning, Macharis & Trip (2004), research on operational terminal efficiency mainly focused on a portion of productivity measurements until the late 1990's such as vessel turnaround time, yard or crane productivity. Later on, researchers displayed a rising interest in techniques to assess the overall terminal efficiency. Roll & Hayuth (1993) have applied a tool to measure port performance and efficiency in the seaport environment, known as Data Envelopment Analysis (DEA).

Bulk and break-bulk terminals are known as multifaceted service establishments and consist of extensive lists of outputs and inputs distinguishing the operations of the terminals. It is challenging to determine the efficiency and the degree to which the terminal's resources are entirely misused in accomplishing the goals of operational performances, due to the terminal being multifaceted.

According to Merk & Dang (2012), port performance is the most important concern on a regional foundation, where there is opportunity that cargo can be diverted to a more competitive and efficient port.

Table 2.3 displays local and international ports that vessels which have called in South African ports have also called in those ports for handling dry bulk and break-bulk. It indicates a group of the most visited 'last' and 'next' ports of call for vessels that call at South African ports. Maputo and Port Louis have become competitors for South African ports in the dry bulk cargo handling ports, whilst the "hub" port in

Singapore, India and China are international competing ports. The rest of the ports are not seen as competitors at present, even though they are visited by vessels also calling in South Africa (Merk & Dang, 2012).

Table 2.3 Ports visited by most vessels calling at South African Ports - 2013/14

| Dry Bulk | Break Bulk |
|---|---|
| Singapore | Singapore |
| India | Maputo |
| China | Walvis Bay |
| Maputo | Luanda |
| Mundra | Dar-Es-Salaam |
| Rotterdam | Beira |
| Mombasa | Abbot Point |
| Qingdao | Mombasa |
| Karachi | India |
| Port Louis | Lagos |

Source: Adapted from Merk & Dang (2014, p. 27)

Vessels that call at international ports also visiting South African ports are illustrated in blue and the ones displayed in green are local ports in table 2.3. The international ports are mostly from the Far-East and South Asian regions.

Maritime trade is measured by an unrelenting quest of reduced costs in order to compete successfully in international markets. Ports need to lessen their turnaround times due to heightened competition. Delays and uncertainty in the material handling process of cargo can inhibit certain competitor's involvement in the international market networks. Cargo dwell times within terminals, vessel waiting time at anchorage (indication of port congestion), vessel turnaround times and cargo handling rates are significant indicators that measure port efficiencies. Focussing on and resolving a terminal's operational performance inefficiencies based on these indicators, can result in positive effects on reducing terminal costs and ensuring adequate capacity is made available.

According to a study conducted by the Organization for Economic Cooperation and Development (OECD, 2014), the average vessel turnaround time of global ports was 1.03 days in 2014 with the majority of ports attaining an average vessel turnaround time lower than 2 days. Asian ports had achieved a VTAT of less than 1 day and Japan had achieved an average VTAT of half a day. The average VTAT of global ports is illustrated in Table 2.4.

African ports usually have lengthier VTAT's, as in the Port of Mombasa having an average VTAT of 4.1 days when compared to the ports in South Africa of 3 days (OECD, 2014).

Table 2.4 Vessel Turnaround Time of Global Ports

| Port | 2014 Average VTAT (Days) |
|---|---|
| Kelang | 0 - 1 |
| Tanjung Pelepas | 1 - 2 |
| Singapore | 1 - 2 |
| Shanghai | 0 - 1 |
| Yokohama | 0 - 1 |
| Hamburg | 1 - 2 |
| Le Havre | 0 - 1 |
| Rotterdam | 1 - 2 |
| Bremerhaven | 0 - 1 |
| Felixstowe | 0 - 1 |
| Antwerp | 1 - 2 |
| Genoa | 1 - 2 |
| Barcelona | 0 - 1 |
| Valencia | 0 - 1 |
| Gioia Tauro | 1 - 2 |
| Algeciras | 0 - 1 |
| Tangier | 0 - 1 |

Source: Adapted from Merk (2015, p. 183)

Ports reflected in table 2.4 manage the bulk of the cargo volumes in international trade and trade through routes that can accommodate larger vessels. South African ports generally handle much smaller volumes of cargo when compared to global Ports. The average VTAT of the South African ports display that there may be challenges faced when compared to some of the global ports and the cascading effect of larger vessels on the South African trade route.

According to Raballand et al. (2012), the dwell time records of cargo at a terminal have become a key marketable tool to attract cargo volumes and generate income. From the perspective of the capacity of terminals, cargo dwell times that are high may be used to validate the expansion of the terminals capacity, subsequently, improving the cargo dwell times would reflect positively in creating terminal capacity without prior investment required to physically expand (Raballand et al., 2012). The result of improving dwell times will reduce logistics costs significantly. The dwell times in the bulk and break bulk sector of South Africa's ports are reflected as a benchmark for other ports in the Sub-Saharan region (Ports Regulator, 2016). There has been substantial improvements made in decreasing cargo dwell times to 3-5 days for bulk and break-bulk exports and imports and marginally longer for transhipment cargo (Ports Regulator, 2016).

Figure 2.4 illustrates the cargo dwell times of South Africa's Bulk and Break-bulk ports in comparison to the rest of the Sub-Saharan African country's ports.

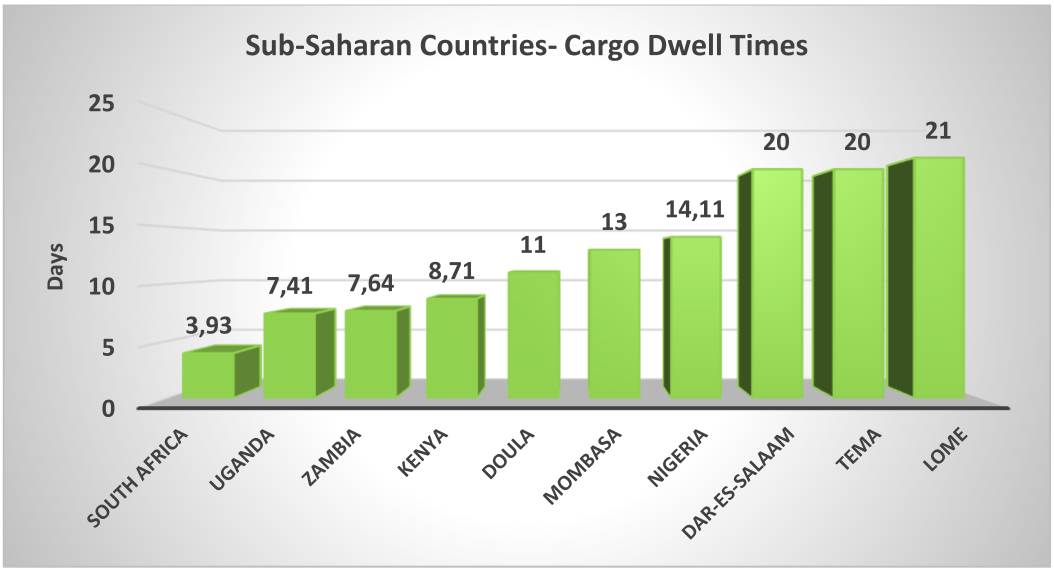


Figure 2.4 Cargo Dwell times at Sub-Saharan Terminals

Source: Adapted from Raballand, et.al. (2012)

Although there are countless challenges experienced through transactional, operational and storage aspects that have a direct impact on cargo dwell times within the terminal, the Port of Durban's dwell time performance is on par with most international ports (Raballand et.al., 2012).

## 2.9 Optimising Bulk minerals operations at Port Terminals

Bulk commodities transported from pit to port and port to vessels on the export leg operations can be lengthy and complex, the performance of activities or elements within the process can sometimes have an impact on the proceeding activities within the chain of activities and overall impact the end result of meeting established targets. To optimize the logistics flow of activities within the chain, it is important to have a clear understanding of the connections amongst the various elements, the responses to changes of characteristics of the elements and how well the operating model is suited to gain best performance. The bulk commodities export leg generally contains numerous logistics activities such as processing and product classification. These activities are structured through an integrated network of storage facilities that are situated at the mine, the port and storage facilities close to the port. The storage facilities are important in preventing unforeseen changes in the overall process of moving the commodity from the mine to the port. Key performance decisions need to be made that have an influence on the behaviour of the operations regarding handling rates of the commodities and equipment used during the material handling process, the time taken to move the commodity from one transport mode to another including storage, the number of optimal resources allocated for the operation and the transport or equipment capacity such as rail, vessel and trucks (Leech 2017). Each element measured needs to be analysed for cost effectiveness, after which an informed decision will be made.

An area often neglected in the port system network is the port/rail interface. In recent years there has been more emphasis on enhancing operational performances at the port/rail interface due to the number of benefits for the customer and the port environment itself. At Transnet, trains are manged by Transnet Freight Rail (TFR). Arriving trains are placed and stored at TFR’s yard which is in a close proximity to the port, this occurs as a result of Transnet having multiple stations and in this way operations can be controlled, preventing congestion. Transnet Port Terminals (TPT) will place an order with TFR to call in the trains when required, a locomotive and rail shunt car will shunt in the train wagons to be placed along the terminals siding to access the wagons for operations. Once operations have complete, TPT planners will contact TFR to place a release order for the empty/full wagons to be shunted out into TFR’s yard from where the train will depart to the customer or inland terminal. In order to enhance the port/rail synergy, it is important to explore alternative solutions that may involve additional stacking areas or even a stockpile strategy within the port. Such solutions may prove to be economical by enhancing the efficiencies, reducing turnaround times and reducing costs.

## 2.10 Summary

The literature review undertaken has provided an in-depth understanding of lean theory and its tools and techniques that will enable an enhanced and efficient port environment. Conventionally, lean has been understood as an opportunity for ports to enhance and improve operational efficiencies and to create an innovative and fresh platform for competitiveness. Since its inception, lean theory has been the most influential way of working in the manufacturing industry and of recent years been it has been emphasised in the service industry. The basis behind the lean philosophy is the elimination of waste which encompass an overall system efficiency, continuous improvement, value-added activity benefits for the customer and respect for individuals. Just-in-time, VSM, cost and (TQM) techniques were the main focus areas during the inception of lean theory and later on moved towards abstract concepts of strategy and philosophy. The port industry plays an important role in global trade through the various types of port terminals and contributes significantly to the economy of the country. Therefore, it is imperative for ports to handle cargo efficiently which can be controlled and monitored through performance indicators. For the bulk and break bulk industry, optimization of the logistics chain is necessary through port/rail synergies in minimising overall costs and sustaining a competitive market spot. Not many studies were found on implementing a lean philosophy in the seaport industry to improve operational efficiencies. It was challenging to identify and compare gaps, however, this study will contribute to the expansion of the knowledge base regarding the effective implementation and managing the lean bulk approach at the Port of Durban. The research methodology used for the investigation of this study is discussed in chapter three.

# CHAPTER THREE

# RESEARCH METHODOLOGY

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## 3.1 Introduction

Research methodology is a method of scientifically solving a research problem and it may be thought of as a discipline of learning how research is conducted scientifically. It comprises of defining and redefining problems, formulating hypothesis, suggesting solutions or approaches to solutions, gathering and analysing data, deriving, conducting experiments and finally authenticating the hypothesis or deducing new conclusions. Kothari (2004), defines research as a search for knowledge through objective and logical methods of finding solutions to problems or establishing foundational philosophies. According to Kothari (2004), research is an art of scientific exploration and a transformation from the known to the unknown and, therefore, a journey of innovation. This chapter seeks to provide an understanding into the research methodology used and the method in which data was collected for this study. In chapter two, the literature review identified and defined various issues such as poor performance and operational inefficiencies **in** the port industry. As lean philosophies within a seaport context is not commonly discussed and understood, the research methodology needed to be designed in such a way as to ensure that the objectives of the study on a lean approach to enhance operational efficiency at the Bulk and Break-Bulk Terminals at the Port of Durban were adequately addressed. This chapter will include the aims and research objectives, research design and methods, study setting, how data was collected and analysed and ethical considerations.

## 3.2 Aim and Research Objectives

### 3.2.1 Research Aim

The purpose of this paper is to explore the approach of using the philosophies, tools and techniques of lean, in the effort to drive and enhance operational efficiencies in the bulk and break-bulk terminals at the Port of Durban. Bulk and break-bulk terminals through intermodal facilities have an important part to contribute in the current global multifaceted supply networks. In the event of challenges experienced within the terminal such as operational inefficiencies, the resultant bottlenecks remain a major and regular encounter from attaining and exceeding key performance targets. Improving the operational efficiency and effectiveness of bulk and break-bulk terminals not only assists the profitability of the organization but also has flow-on benefits for the organizations internal stakeholders, external stakeholders such as customers, shipping industries, ship's agencies, other operating divisions and the environment.

### 3.2.2 Research Objectives

The objectives of this study is the guiding framework within which this research is undertaken and the following chapters of this dissertation will be fundamentally guided by the objectives.

The objectives of this study are as follows:

1. To examine from literature on the lean principles that can be implemented to improve efficiency in a Bulk and Break-Bulk environment

2. To analyse the current operational performance levels at the Bulk and Break-Bulk terminals at the Port of Durban

3. To study the material handling operations of bulk manganese through direct operational observations at the Bulk and Break-Bulk terminals at the Port of Durban

## 3.3 Research Methods and Design

### 3.3.1 Research Methods

Research is a logical and structured form of constant responsiveness used in a field of knowledge, conducted to establish facts, associations, ideologies and concepts (Denscombe, 2010). According to Clarke (2005), research is an advancement in one's thoughts and beliefs and approaches to a phenomenon; considering additional sources of information with the intention to explore a notion, investigate an issue and resolve a problem. Fundamentally, the researcher needs to carry out a comprehensive investigation of the circumstances around the research problem by acquiring a thorough understanding of the problem on hand. According to Denscombe (2010), the study should put the researcher in a position to deliver an all-encompassing understanding of the circumstances around the research which is unbiased, trustworthy and factual by conducting accurate research through the application of data collection and analysis techniques.

According to Clarke (2005), there are various types of research methods which one can utilise for research, namely:

- Descriptive research: Aims to describe with higher accuracy and precision which is usually quantitative. Uses surveys, comparative and correlation methods.
- Exploratory research: Aims to explore subjects with little prior knowledge and to research surface key issues to form a basis for further research.
- Analytical research: Analyses and makes critical evaluation of information.
- Applied research: Addresses practical problems and solutions that can be implemented for near-term benefits.
- Fundamental research: Generalization and formulation of theories.
- Quantitative research: Provides numerical results to validate the claims.
- Qualitative research: Comparative development of enhancing the usage patterns and experiences.
- Mixed Methods research: is a combination of more than one research method to effectively address the research problem.
- Conceptual research: Abstract ideas or theories.
- Empirical research: Relies on experience and observations.

The application of the type of research method is highly reliant on the nature of the research problem.

According to Miller & Meece (1997), the motivation behind conducting research is to gain:

- Intellectual satisfaction of doing something innovative and creative.
- Meaningful and long-lasting contributions towards the advancement of mankind and society.
- Enjoyment of challenges of solving unsolved problems.
- A higher level of understanding of fundamental concepts as well as practical significances.
- Degrees, financial benefits, and respect that comes along the way.

#### 3.3.1.1 Quantitative Research:

The purpose of quantitative research is to examine the relationship between variables such as independent, dependent and extraneous characteristics and is a resultant from a positivist framework. Independent characteristics are characteristics that are manipulated by the researcher, dependent characteristics are characteristics that are impacted by the manipulation of the independent variable, extraneous characteristics are variables that are extraneous towards what the researcher is focusing on which is usually demographic information. According to Best & Khan (1989), quantitative research is based on its original strategies and the results are readily examined and interpreted. The data for quantitative research is usually obtained in the form of numbers and these numbers are recorded from instruments that people use to measure such as surveys, questionnaires or historical data.

#### 3.3.1.2 Qualitative Research:

The purpose of qualitative research is to explore the meaning of people's experiences, the meaning of people's cultures and the meaning of how people view a particular issue or case. According to Denzin & Lincoln (1994), qualitative research suggests an importance on processes and meanings that are not thoroughly reviewed, measured in terms of capacity, volume, strength or frequency.

Researchers collect more than one kind of data for each study and data is collected mostly in the form of words. The data is usually obtained from interviews, documents such as newspapers and journals, observations and audio visual material such as videos and recordings (Creswell, 2014). All this data is gathered from the 'field' which is the natural settings were participants are. Researchers go into the field and spend a lot of time interviewing and observing the participants in their environments. A hallmark of qualitative research is its emergent design, which means that the method used to conduct the research can change during the study.

#### 3.3.1.3 Mixed Methods Research (Triangulation):

Mixed methods research is a methodology used for conducting research that comprises collecting, analysing and incorporating quantitative and qualitative research into a single study or a longitudinal platform of analysis. The motivation behind this form of research is the incorporation of both qualitative and quantitative research techniques to provide an enhanced understanding of the research problem and its perspectives (Flick, 2006). According to Johnson & Onwuegbuzie (2007), an advantage of using a mixed methods approach is that researchers can use all available tools to collect widespread data. This results in a comprehensive perspective of the complete research problem.

### 3.3.2 Research Methods applied in this Study

For the purpose of this research, a mixed methods research approach was used. This study is best suited to both quantitative and qualitative research methods as using one type of research method such as qualitative could result in a biased perspective, therefore to counteract this challenge, a mixed methods/triangulation approach was used. Due to the limited number of bulk and break-bulk ports in South Africa, there is insufficient information relating to lean implementation in enhancing operational efficiencies. This study necessitates results in terms of operational performances that requires to be measured and quantified by numbers.

A quantitative approach was used to conduct an analysis of secondary data collected from operational performance reports. The study also requires observations of the elements being measured in order to reach objective informed decisions and deduce conclusions through a qualitative approach. Under the qualitative approach, measuring the operational performance is process-oriented and requires business process mapping and process activity based charts, which is the management of process events, activities and decisions that eventually add value to the organization and its customers (Kaplan & Norton, 1996). These events, activities and decisions are referred to as processes (Dumas, La Rosa, Mendling & Reijers, 2013). The combination of both the quantitative and qualitative approach provides more evidence and will enable sufficient information to achieve the research objectives.

### 3.3.3 Research Designs

Research design's main area of focus is on the elements or activities in a process that contributes to accomplishing the end-product and the final service or product at the end of the process. According to Welman, Kruger & Mitchell (2009), research design is best referred to as the all-inclusive strategy according to which the contributors of a planned study are chosen, including the method or technique of data collection. Babbie & Mouton (2008) define research design as a proposal or blueprint used to undertake the research. The research design involves a comprehensive plan in alignment to the type of research conducted. Mouton (1996) states that the key purpose of a research design is to facilitate and assist the researcher to forecast and foresee the outcome of suitable research solutions and to capitalize on the validity of the ultimate outcomes. There are various types of research designs that can be used which are aligned to the type of research being conducted such as experimental, survey, comparative, case study, observational, action research and mixed methods design.

For the purpose of this study, the research design used were observational design and mixed methods design. Observational design is when the researcher collects data by looking at elements during an operational process (Burns & Grove, 2001). Observational design can be quantitative or qualitative, performed merely as an observer or participant depending on what the researcher thinks is best and what the research objectives are. Mixed method design is the study of different data collection methods used or different research designs combined (Burns & Grove, 2001).

Providing a meaningful research design will enable the study’s objectives to be satisfied, through the analysis of the nature and complexity of the research problem and associated research objectives. Burns & Grove (2001) are of the view that a research design will assist the researcher to achieve the end-result of implementing the objectives of the study and will subsequently improve the probabilities of attaining detailed facts that are aligned to the actual problem being researched. In-order to improve the quality, variety and scope of the study, a mixed methods research design was selected to undertake this study through direct observations from operations and secondary data analysis from historical data.

Illustrated in figure 3.1 below is the instrument development option of the research design model developed for the study. The research findings from the data collected, is used to develop and implement a lean framework and lean programme.

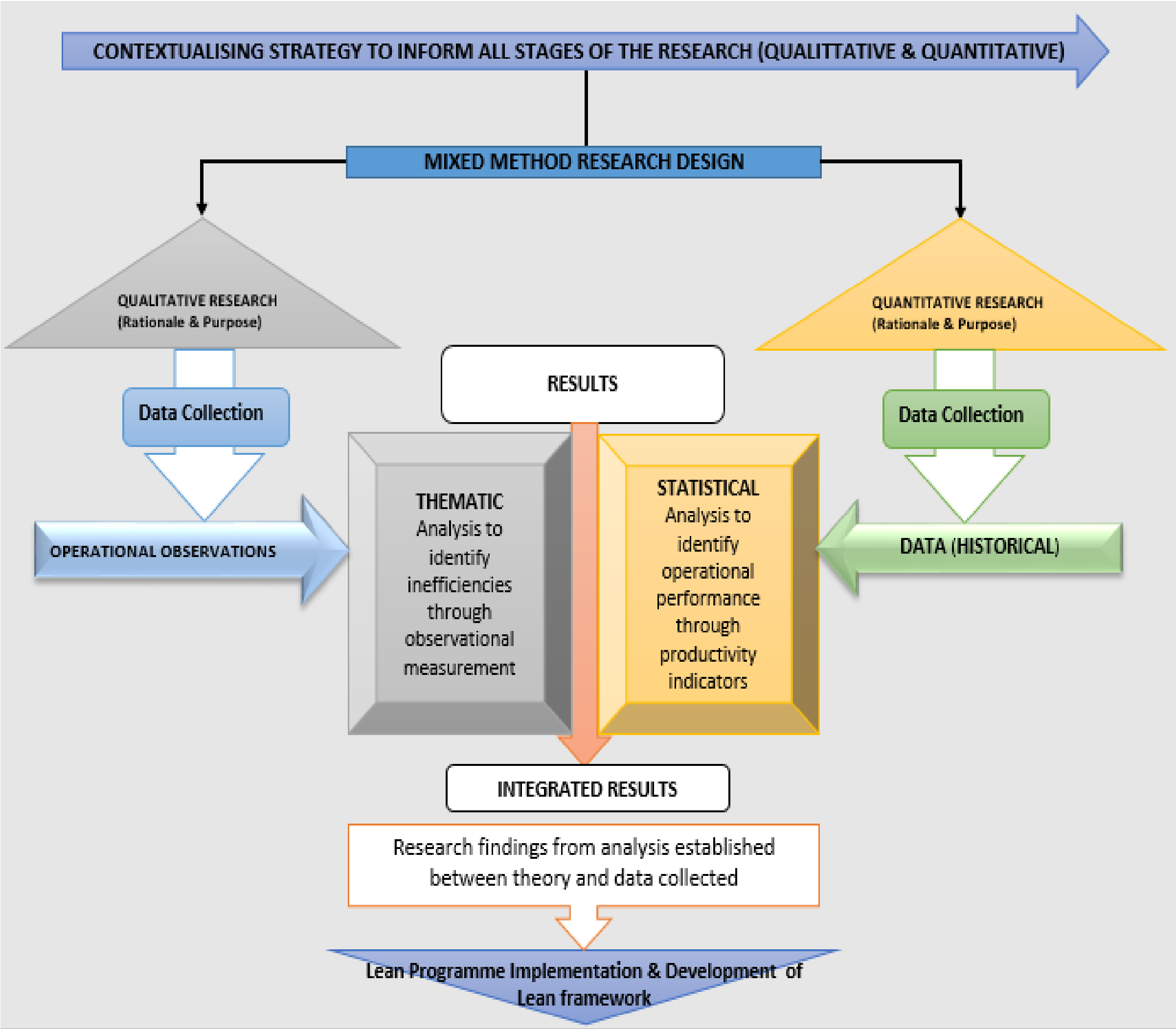


Figure 3.1 Research Design – Mixed Methods Model

Source: Compiled by author

## 3.4 Research Paradigm

Terre Blanche & Durrheim (1999) state that research methods have three key elements: ontology, epistemology and methodology and a research paradigm is a comprehensive system of interconnected practice and intellect that describes the type of investigation within the three elements. According to Kuhn (1962) the term research paradigm is defined as a set of traditional theories and understandings common amongst scientists and signifies a conceptual framework on the basis on what methods should be used to comprehend and address problems. The term paradigm represents a research ethos with beliefs, ethics, standards, values and expectations that a group of scientists have in common relating to the background and conduct of the research (Kuhn, 1977). According to Olsen, Lodwick & Dunlap (1992), the term paradigm suggests a design, charter and framework or systematic principles of scientific and theoretical concepts, beliefs and assumptions. The origins of qualitative and quantitative research methodologies encompass various theoretical research paradigms, specifically positivism and post-positivism. Post-positivist methods display a far superior transparency to diverse methodological approaches, which frequently comprise qualitative and quantitative methods. Post-positivism is categorised by two other paradigms which is interpretivism and critical theory, however pragmatism is perceived as a link between positivism and post-positivism (Blumberg et al., 2008). For the purpose of this study, the best suited research paradigm is positivism and post-positivism on the basis of the mixed-methods research method used.

Positivism is perceived as a way to social research that pursues to practise the natural-science framework of research for investigations of social occurrences and portrayals of the social biosphere. Positivism involves a belief established on the perception that trends, generalities, approaches, techniques, cause-and-effect challenges are also pertinent to social sciences. This interpretation of positivism upholds that the elements of social sciences such as people and activities are appropriate for implementing scientific techniques. According to Morris (2006), the positivist researcher sustains that it is probable to assume an unbiased, isolated, detached, non-interactive and impartial position when conducting the research. Assuming this position will permit the researcher to take on an objective analytic role to interpret the data in an unbiased manner, presenting a true reflection of the occurrences.

According to Drukman (2005), positivists have a quantifiable preference of analytically interpreting the data. Positivism also involves a view that authentic information can only be composed on the foundation of direct observations of activities through sight which also consists of the capability to measure and capture the information first hand. Data collected through observations, means permitting only empirical evidence as authentic evidence and establishes that there is no valid data for activities or occurrences which have not been witnessed, through experience and direct observations, or indirectly, with the assistance of tools and instruments. For the relevance of this study, a positivism approach was adopted as data was collected from direct observations and was captured from first hand.

## 3.5 Study Setting

This study is undoubtedly significant as the Maritime Industry plays a vital role in contributing towards trade and industry and the economic growth and development of South Africa. There is a significant demand for bulk and break-bulk commodities carried on vessels which cannot be transported in regular containers that move through the Port of Durban. This freight segment has become greatly specialised to accommodate consignments of bulk and break-bulk cargo which have become larger and heavier and the existing gear on the bulk and break-bulk vessels have improved. This study was conducted at the Port of Durban which has two multi-purpose terminals (MPT), situated at Point and Maydon Wharf managing bulk and break-bulk commodities such as bulk minerals, steel, ferro-alloys, granite, rice, forest products, fertiliser, fruit, grain and containers through import and export operations and explores the material handling operations of transferring cargo from or to vessels, rail, road transport and stockpile. The Port of Durban has in current years positioned itself as the country's 'hub port' with superb port, road and rail connections into the hinterland and along the coastline of South Africa. The study seeks to benefit all stakeholders within the bulk and break-bulk sector of the maritime industry as the findings from the study will provide an in-depth knowledge on daily operational implications on factors enhancing bulk and break bulk terminal efficiency. The results will provide direction for future studies and practical inferences, particularly to researchers conducting similar studies in using a lean approach to enhance the operational efficiency at the bulk and break-bulk terminals. Finally, the study will be of value to the economy, the South African government, other African countries and bulk and break-bulk terminals nationally that experience similar challenges with terminal inefficiencies. Once Implementation of recommendations from the research are administered by relevant authorities, challenges can be adequately addressed and inefficiencies reduced and eliminated consequently enhancing the productivity of the port terminals.

## 3.6 Population and Sampling Method

According to Sekaran (2010), a population is a complete collection of people or things such as resources, of interest that the researcher focuses on to analyse or measure. Mugenda & Mugenda (2003) defines a population as a total group of people or items having mutual observable characteristic. The study therefore encompassed operational activities and resources involved in the material handling operations of bulk minerals such as manganese. The target population comprised operational performance reports for seven months of the current financial year from April to October 2017.

According to Cooper & Schindler (2003), the sampling frame in research is the list of all population elements from which the sample is chosen. Sampling methods are categorized into two main categories which are commonly known as (i) probability sampling methods and (ii) non-probability sampling methods. In probability sampling, every participant of the population has a known probability of being involved in the sample and comprises of Simple, Systematic and Stratified random sampling as well as Cluster and Multistage sampling. In non-probability sampling, every element of the population does have an equal opportunity of contributing in the research and comprises of Volunteer, Convenient, Purposive, Quota, Snowball, Matched and Genealogy based sampling techniques.

For the purpose of this study, an activity sampling technique was applied. Activity sampling is a method that comprises a large number of observations, over a period of time of one or a group of equipment, processes or labour. For each observation, the occurrence is recorded immediately upon observation and the percentage of observations recorded for a specific activity or delay is a measure of the percentage of time that that activity takes place. According to Brisley (1971), activity sampling works as a result of a smaller number of occurrences have a tendency to follow the similar distribution design that a greater number produces. Muhlemann, Oakland & Lockyer (1992), states that the accuracy of activity sampling is dependent on the number of observations. Insufficient and infrequent observations will result in a reduced level of accuracy, whilst numerous and frequent observations will provide a much precise and more exclusive information. A report was compiled from direct observations conducted by observers. The operational process of the material handling of bulk manganese was studied over a period for one consignment, each activity within the process was fragmented into elements. An element is a step in the entire process, for example: the forklift placed the container onto the trailer. A number of 64 observations were conducted per element and the amount of time that the element took to complete the activity was recorded. A performance report was compiled with the cycle times per element in the process.

It is imperative that the observer determines the optimum number of observations required for the study. The number of observations was calculated statistically once an estimated representation of the situation was recognized, using the formula below with a 95% confidence level:

$$N = \frac{4P\ (100\text{-}P)}{L^2}$$

Where N = the number of observations

P = the approximate occurrence of activity as a % of N

L = the acceptable accuracy in occurrence of the activity being studied as a percentage

For example, P = 80% (% of activity performed optimally)

L = 10% (±Tolerance level or acceptable error %)

Therefore the number of observations:

$$N = \frac{4 \times 80(100\text{-}80)}{10 * 10}$$

$$= \underline{64 \text{ observations}}$$

The total population of the study was 80 cycles per element. At 95% confidence level, a sample size of 64 transactions per cycle was observed and the time was recorded to complete each cycle.

## 3.7 Construction of the Instrument

According to Russell & Taylor (2005), work based time observations are specifically essential for precisely measuring the performance of an operation taking into account the various resources that is the focus of the Kaizen. A time observation instrument records all the segments that were noted on the current process and the cycle time for each element independently. A time study observation log sheet was used to record and collect data for the study. Materials and equipment needed for the study: stop watch, clip boards, time observation sheet, operational layout, stationery – pen, pencil, eraser and calculator. The information required to be recorded on an observation sheet is the name of labour, equipment name and number, task/job performed, operational area, element of work activity, observers name, time and date of observation, general information about activity performed etc. Each operational activity is divided into a number of elements which is done for easy observation and accurate measurement. The time taken to complete each element within the process is recorded for every observation within the cycle. Once the observation has been completed, the data collected was analysed.

Table 3.1 Data collection tool – Time Study Observation Log

| Tiper Truck(TT) arrival time | Skip no | skip tonnage | TT Queueing time | Skip Start loading | Skip Finish loading | Total Loading time | TT Departs Loading | Delay time (min.) | Delay Reason |
|---|---|---|---|---|---|---|---|---|---|
| 07:47 | 6 | 20 | 00:03 | 07:50 | 07:54 | 00:04 | 07:57 | 6 | 07:57 -08:03 Waiting for TT |
| 07:47 | 9 | 20 | 00:03 | 07:54 | 07:56 | 00:02 | 07:57 | | |
| 08:03 | 4 | 20 | 00:01 | 08:04 | 08:06 | 00:02 | 08:09 | 3 | 08:15-08:18 waiting for TT |
| 08:03 | 2 | 20 | 00:01 | 08:06 | 08:08 | 00:02 | 08:09 | | |
| 08:10 | 7 | 20 | 00:00 | 08:10 | 08:12 | 00:02 | 08:15 | 2 | 08:18-08:20 TT positioning |
| 08:10 | 11 | 20 | 00:00 | 08:13 | 08:14 | 00:01 | 08:15 | | |
| 08:18 | 6 | 20 | 00:02 | 08:20 | 08:22 | 00:02 | 08:40 | 10 | 08:24-08:34 Waitng for TT |
| 08:18 | 9 | 20 | 00:02 | 08:22 | 08:24 | 00:02 | 08:24 | | |
| 08:34 | 2 | 20 | 00:01 | 08:35 | 08:37 | 00:02 | 08:40 | 8 | 08:40-08:48 Wating for TT |
| 08:34 | 4 | 20 | 00:01 | 08:37 | 08:39 | 00:02 | 08:40 | | |
| 08:48 | 6 | 20 | 00:02 | 08:50 | 08:52 | 00:02 | 08:55 | 2 | 08:48-08:50 TT positioning |
| 08:48 | 9 | 20 | 00:02 | 08:52 | 08:54 | 00:02 | 08:55 | | |
| 09:00 | 7 | 20 | 00:00 | 09:00 | 09:03 | 00:03 | 09:06 | 5 | 08:55-09:00 Waiting for TT |
| 09:00 | 11 | 20 | 00:00 | 09:03 | 09:05 | 00:02 | 09:06 | | |
| 09:16 | 4 | 20 | 00:01 | 09:17 | 09:19 | 00:02 | 09:21 | 10 | 09:06-09:16 Waiting for TT |
| 09:16 | 2 | 20 | 00:01 | 09:19 | 09:21 | 00:02 | 09:21 | | |

Source: Author created - TPT CI (2017)

Table 3.1 illustrates a sample of the data collection tool that was created to collect the observed times per activity within the export process of bulk manganese to be loaded onto the vessel. Displayed on the tool are the elements that were observed are such Tipper Truck (TT)  arrival time at the stockpile, tons loaded into skips, TT queueing time, start of loading , end of loading, TT departing loading zone and the delays.

## 3.8 Data Collection

Andrews, Higgins, Andrews & Lalor (2012), state that in a period where huge volumes of records are being collected and archived by scientists globally, the reality of utilizing existing data for research purposes is becoming much more predominant. The concept of secondary data analysis, is analysing data that has been gathered by someone for another prime purpose. Researches who have insufficient resources and time constraints, recognise the use of secondary data as a feasible option. The analysis of existing data is an experimental or observational exercise that utilizes the identical fundamental research philosophies as the primary data studies utilized and contains phases to follow as any other research method. According to Babbie & Mouton (2007), data used in secondary research is found in primary and secondary repositories that currently exist as a result of information that has previously been composed by organizations, agencies and individuals for a previous project or study other than the current research being conducted.

Secondary research techniques for data gathering: secondary data was used from existing data which was collected from direct time study observations conducted previously, complementing the primary data. Observations were conducted for operational studies to form part of improvement projects within the organization through time studies. The secondary data was obtained from the Continuous Improvement department and Management Information System (MIS) department within the Durban bulk and break-bulk sector of TPT. The data collected involves the recording of operational times of the various activities in terms of elements within the process as well as operational delays and actual operational performances. Another data collection instrument analysed, was a tally sheet in the form of recording operational delays, first lift and last lift of operations, the volumes handles, the operational times, equipment numbers, etc. There are various material handling operational processes at the bulk and break-bulk terminals. For the purpose of this study, data collection will be focused on the bulk manganese export operation in detail, i.e. bulk manganese from rail to stockpile/stockpile to vessel.

## 3.9 Data Analysis

Data analysis is a method of establishing answers to questions through the analysis and interpretation of data collected. There are numerous ways to interpret raw data from direct observational research. The simplest way is to compute frequencies of activity occurrence and intervals of the different categories of activity. The fundamental steps in the analytic method comprise of recognising issues, clarifying the accessibility of appropriate data, determining which techniques are appropriate for answering the questions of concern, apply and evaluate the techniques, review and publish the results. The manner in which data was analysed was both quantitative and qualitative. Quantitative analysis was done for the numerical data obtained from the field. This was conducted using descriptive statistics with the help of Microsoft Excel and Minitab project and was presented in the form of tables, graphs, frequency distributions and percentages of each element within the process. The data collected was used to illustrate a visual representation by graphs and tables, and the results are presented in chapter 4.

## 3.10 Reliability and Validity of the study

Reliability and validity of research data is important when conducting data collection. According to Patton (1990), validity makes reference to the degree to which observations correctly capture the activities of which the researcher is interested in. One characteristic of validity is reliability. Reliability is the consistency of observations; such as when two or more observers or the same observer during different occurrences, reviewing the same activities results in the same data. Unreliable observational methods have a high probability to result in invalid data. In seeking to establish the reliability of the data collected from the observer, replication was used to validate the data collected. A sample of the study was repeated using the same procedures with different observers. The data was validated as the replication resulted in the same results. Triangulation was also used by comparing data collection instruments from alternate sources in order to validate the reliability of the data. By applying various collection methods, researchers are able to moderately improve the reliability of the output (Denzin, 1989).

## 3.11 Bias

In research, bias arises when a systematic error is applied in sampling or testing by choosing or influencing one result or response over others. Bias can take place at any stage of a research study such as the design phase, collection of data and during the progression of data analysis and implementation of the study. Bias experienced during the study was collecting data over a lengthy period and the inconsistency of labour due to the change of shift which exposed observers to different events or experiences that may have influenced them outside the conditions of the experiment. To prevent this type of bias, the same type of operation with a consistent set-up of resources was observed and observations were conducted over same shift patterns.

## 3.12 Ethical considerations

Ethical considerations are critical in research. According to May (2011), ethical morals prevents false and dishonest data from being produced and thus encourages the search of true and accurate information which is the fundamental objective of research. Ethical conduct is imperative for collaborative work as it motivates for an organizational culture of mutual respect between researchers, accountability and trust. Ethics is vital when establishing aspects related to sharing of data, copyrights, confidentiality and co-authorship.

All ethical issues were considered for the purpose of this research. The research proposal was submitted and presented to the ethical clearance committee at the University of KwaZulu-Natal (UKZN) Graduate School of Business and Leadership. The committee at UKZN approved the research study and granted an ethical clearance certificate with full approval (see Appendix 1).

## 3.13 Summary

The purpose of this chapter is to describe the research methodology and research design employed for this study. The aims and objectives were explained and the data collection strategies discussed. The methods used were data analysis of secondary data, work based activity sampling through direct observations of operational processes, Business process mapping and activity process charts This chapter also took into consideration the reliability and validity as well as bias of the data collected and ethical considerations to conduct the study and present the findings. The reason behind the choice of data collection instrument was also presented. In alignment with a lean approach, Business process maps and activity process chart methods contribute to the identification of wastes, non-value adding activities within a process and establishing the standard cycle time of an activity. This results in informed factual decisions, enhancing efficiency, productivity and increased profits. The analysis and presentation of the results and findings are discussed in chapter 4.

# CHAPTER FOUR

# PRESENTATION & DISCUSSION of RESULTS

## 4.1 Introduction

The purpose of this chapter is to present and analyse the data collected from the direct observations conducted on the material handling operation of bulk manganese as well as secondary data obtained, in order to determine the current operational performance levels and establish an understanding of the limitations that hinder the required operational performance at the bulk and break-bulk terminals at the Port of Durban. The results from the secondary data obtained and data collected from direct observations would provide adequate information to achieve the objectives of the study and serve as a guideline to develop and recommend a conceptual lean framework on a lean approach to enhance the operational efficiencies at the bulk and break-bulk terminals at the Port of Durban. The study approached the research objectives from two perspectives. (i) Secondary data - The overall operational performance at the bulk and break-bulk terminals and (ii) Direct observations - The operational performance focusing on material handling of bulk manganese at the bulk and break-bulk terminal.

Section 4.2 of this chapter will focus on the overall operational performance of the bulk and break-bulk terminals at the port of Durban, section 4.3 will focus on the analysis of the bulk manganese operation, the chapter will then discuss some of the limitations that hinder the required operational performance and will then continue to discuss the findings from the results.

## 4.2 Operational Performance

The operational performance of a port terminal is usually measured with regards to the speed with which a vessel is discharged, the handling rate with which the various commodities are handled and the time that the cargo is stored at the port prior to ocean freight, transhipment, freight rail or road hauled to final destinations (González & Trujillo, 2009). According to Leech (2017), terminals management also require performance measurements regarding the extent to which the terminals assets are being utilized and the financial performance of operations. Key Performance Indicators (KPI) that measure operational, asset and financial performances are established relatively to the volume of commodity of the consignment calling at the port and of the volume of the cargo handled on the landside. González & Trujillo (2009) mentions that port efficiency is measured by the actual port performance against the optimal port performance, with a given set of inputs.

### 4.2.1 Operational Performance KPI's

According to Notteboom & Rodrigue (2005), conventional calculations in measuring performance of bulk terminals are not as straightforward as with container terminals, where the unit of measurement is standardised, as a result of the variation and of bulk and break-bulk commodities, complexity of operations and the required handling requests. The current operational performance at the bulk and break-bulk terminal's primary measures of vessel, rail and truck performances are the Vessel Turnaround Time (VTAT), Rail Turnaround Time (RTT), Truck Turnaround Time (TTT) and the handling rate of cargo for import and export, known as Ship Working Hours (SWH). The data for the operational KPI's was collected by operations personnel such as the cargo coordinator who records the information on a data sheet. The data sheet is submitted to MIS where the information is captured on to the General Cargo Operating System (GCOS) and the data is used to compile daily, weekly, monthly, quarterly and annual reports.

#### 4.2.1.1 Vessel Turnaround time

The VTAT is the time that the vessel stays on berth and is calculated from the time of the first lift of operations to the last lift of operations and the time is recorded in hours. The average monthly VTAT is determined by dividing the total hours the vessel worked by the total number of vessels calling at the port in the month as illustrated in figure 4.1 below.

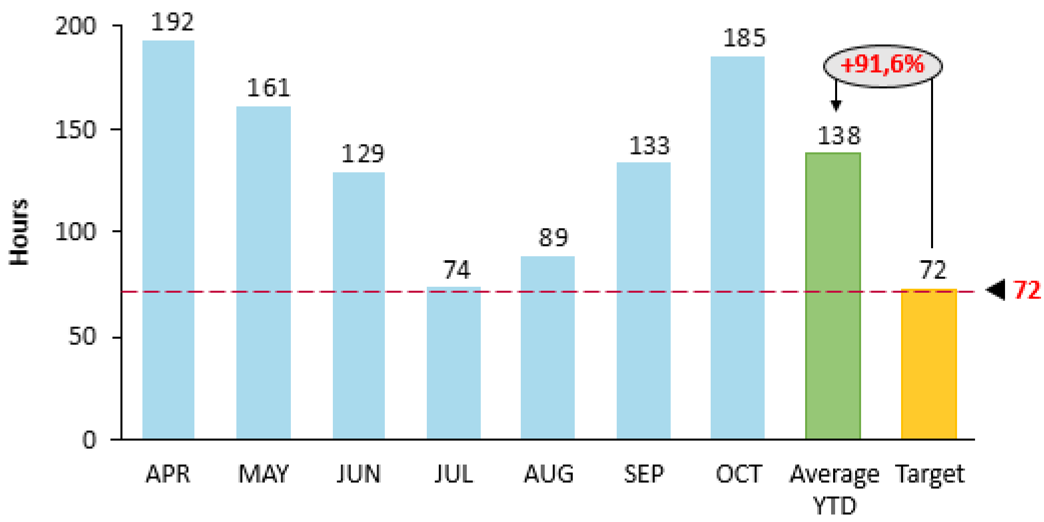


Figure 4.1 Monthly Average Vessel Turnaround Time (Apr-Oct 2017)
Source: Author compiled and analysed data from TPT MIS statistics (2017)

Figure 4.1 illustrates the actual VTAT which is computed on an average per month. The financial year starts in April 2017 and ends in March 2018. Data was collected from April 2017 till October 2017. The design standard time (target) for VTAT was calculated as 72 hours which equates to 3 days. From the data collected, the actual Year to Date (YTD) mean VTAT was calculated to be 138 hours over a period of 7 months. The VTAT performance is poor when compared to the design time of 72 hours, which means that the target was not achieved by 91,6%. The VTAT is influenced by a number of factors such as the quantity of cargo to be loaded or discharged, the capacity land space available such as stockpile/storage capacity, resource planning and the type of cargo being handled.

#### 4.2.1.2 Ship Working Hour

SWH is the actual handling rate of the cargo, measured in tons per hour. The time period of a vessel's stay in port is dependent on the volume of cargo that it has to discharge or load. One of the measures of a vessel’s performance is the tonnage handled per day or hour that the vessel is operational at berth, also known as ship working hour. The average tonnage handled per ship hour was calculated by dividing the total tonnage of cargo that was discharged and loaded by the total number of hours that all the vessels were operational in that month as illustrated in figure 4.2 below.

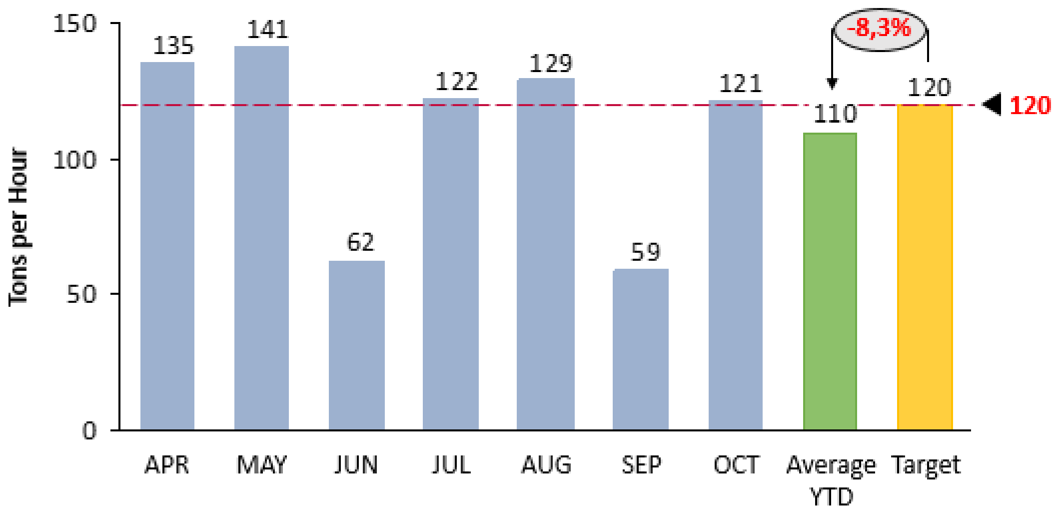


Figure 4.2 Monthly Average Ship Working Hour (Apr-Oct 2017)
Source: Author compiled and analysed data from TPT MIS statistics (2017)

Figure 4.2 illustrates the actual SWH which is computed on an average per month starting from April to October 2017. SWH is also commonly known as the vessels handling rate and is measured in tons per hour (TPH). The design standard handling rate (target) for SWH was calculated as 120 TPH. From the data collected, the actual YTD mean SWH was calculated to be 110 TPH over a period of 7 months. Port performance based on the handling rates displays a trend of underperformance with actual performance rate being below the target. The actual SWH indicated to be an underperformance when compared to the design time of 120 TPH, resulting in the target not being achieved on average by 8,3%. SWH is influenced by the volume of cargo being handle, the type of commodity and weather conditions as well as the planning and allocation of required resources. Often the size and type of commodity being handled has an influence on gang performance. A gang constitutes the crew that handles the transfer of cargo from or to the vessel and on average depending on the size of the vessel, there are 3 gangs that work per vessel. Generally, the larger and more standardised the cargo is, the greater is the productivity.

#### 4.2.1.3 Truck Turnaround Time

One of the key objectives of all terminal is to decrease the time that road trucks wait to be serviced by preventing the terminal's entrance gate from being a bottleneck. The time that the truck spends in waiting to enter the terminal is a result of the port's performance. The gate, yard and quayside activities are the most important elements that occur at the bulk and break-bulk terminals. TTT is defined as the time that the road truck is gated into the terminal till the time the truck is gated out of the terminal, which is the actual time period that the truck is within the terminal. This measure of performance does not include any time spent waiting outside the terminal's gate before entry. The average monthly TTT was calculated by dividing the total time that the trucks spent inside the terminal for a specific month by the number of trucks that entered and left the terminal for that specific month. The average monthly TTT is illustrated in figure 4.3 below.

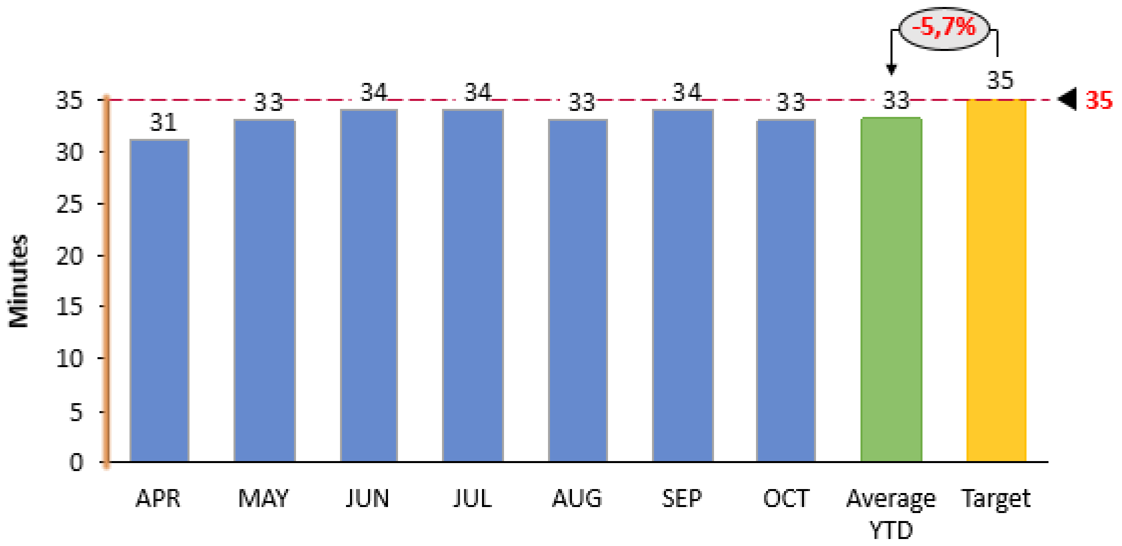


Figure 4.3 Monthly Average Truck Turnaround Time (Apr-Oct 2017)
Source: Author compiled and analysed data from TPT MIS statistics (2017)

Figure 4.3 illustrates the actual TTT which is computed on an average per month starting from April to October 2017. The design standard time (target) for TTT was calculated as 35 minutes. From the data collected, the actual YTD mean TTT was calculated to be 33 minutes over a period of 7 months. Port performance based on the actual TTT displays a well performing trend when comparing the actual performance time to the design time of 35 minutes, exceeding the target by 5,7%. The TTT is influenced by the SWH, VTAT, RTT as well as other sub-activities such as document processing at the weighbridge and verification of documentation by security. TTT performance also indicates the congestion at the terminal. The TTT proved to have a positive performance at the bulk and break bulk terminals which also indicates that port congestion is minimal.

#### 4.2.1.4 Cargo Dwell time

The analysis of a port's performance from the exporter/importer’s understanding, is that there is only one indicator of concern which is the dwell time of cargo. The dwell time of cargo in the port is measured in relation to the number of days or hours that a ton of cargo remains in the port’s stockpile for storage. A high dwell time is usually an indication of issues at the port and does not ascertain areas for improvements, unlike SWH, it does not have a breakdown according to the different processes that needs to be gone through before the cargo can be shipped or delivered (e.g. waiting for instructions, waiting for vessel, waiting for transport, etc.). The status of dwell time also evidently varies with the type of cargo handled. The dwell time is basically the time that cargo is temporarily stored in stockpiles or within warehouses at the terminal; awaiting the next mode of transport such as export onto vessels, import onto rail or onto road trucks to the next destination. The average monthly Dwell time was calculated by the total time that the various commodities were placed onto the stockpile or storage facility within the terminal until the cargo left the stockpile or storage facility within a specific month minus the free storage days. Customers are allowed free storage of 3 days (72 hours). The average monthly dwell time is illustrated in figure 4.4 below.

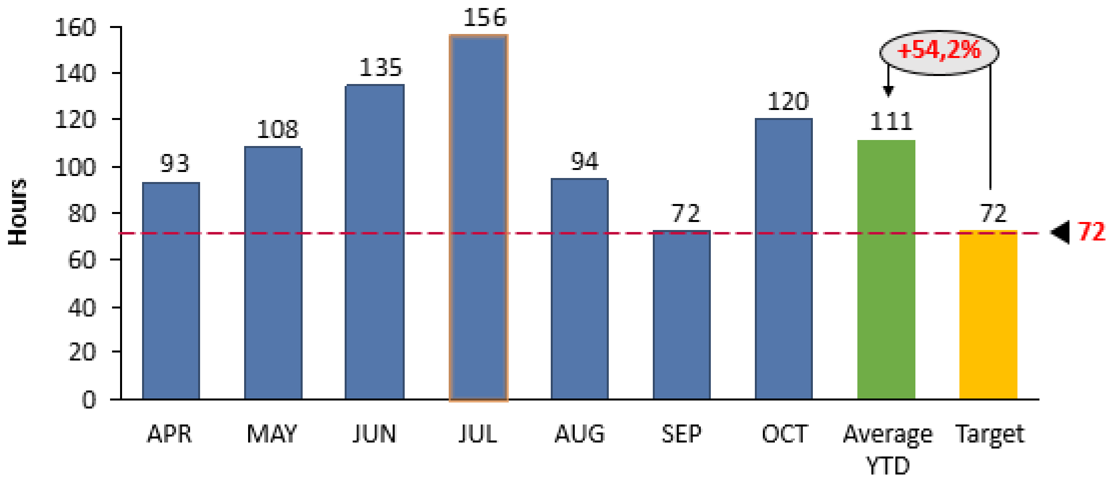


Figure 4.4 Monthly Average Cargo Dwell Time (Apr-Oct 2017)
Source: Author compiled and analysed data from TPT MIS statistics (2017)

Figure 4.4 illustrates the actual cargo dwell time which is computed on an average per month starting from April to October 2017. The design standard time (target) for cargo dwell was calculated as 72 hours. From the data collected, the actual mean YTD dwell time was calculated to be 111 hours over a period of 7 months. The port's dwell time performance based on the actual dwell hours, displays a poor performing trend when compared to the design time of 72 hours, under achieving the target by 54,2%. Dwell times are influenced by service quality, such as commercial customers regularly use the stockpiles or storage areas within the terminal as an overflow node in their supply chain generating a deliberate delay. This condition interferes with dwell time data as some customers temporarily store their export cargo in the terminal well in advance before the time that the planned vessel arrives at the port and could leave the import cargo in the terminal storage facility for a long time after arrival. According to Merckx (2005), the significance of dwell time in bulk and break-bulk terminals are emphasised that reducing half the dwell time of cargo can increase yard throughput by twice the time without investing in new capacity.

The ability of the bulk and break-bulk terminals to attract cargo and grow volumes, subsequently generating revenue which contributes to the country's economy, is dependent on the performance of the port to minimize the VTAT, SWH, TTT and cargo dwell times. The optimization of the capacity of the terminal will facilitate the ports to make use of the ports' infrastructure in a more efficient manner. By utilizing the port's infrastructure efficiently, VTAT will be reduced considerably, permitting ports to attract and manage more vessels. Furthermore, a reduction in cargo dwell time will aid in decongesting the port facilities and upkeep effective yard planning. From the overall terminal operational performance, it is evident that a lean approach is required to enhance efficiencies.

## 4.3 An Analysis of Bulk Manganese Operations

Bulk manganese operations at the TPT Maydon Wharf terminal (Bulk and break-bulk terminal) is an export operation. The manganese export chain involves various modes of transportation processes such as vessel, rail and road. These are integrated through buffer storage or stockpile facilities situated at the terminal. The stockpile facility is essential in assisting in the movement of manganese from pit to port operations. Bulk manganese is transported from the inland mines in South Africa via road trucks and Half Height Containers (HHC) on rail wagons to the stockpile siding at the Maydon Wharf terminal from where export takes place on vessels. Road trucks arrive at the terminal and stockpile the manganese at the buffer storage area within the terminal. Manganese that is transported via rail, is managed by TFR through the rail corridor. The trains are placed at the Maydon Wharf siding by TFR once TPT planners request a "call in" order for the wagons to be placed at the operational area. Planning meetings are held to prepare for the operation which includes equipment and labour allocation. The annual budgeted volumes that will be handled for the 2017/2018 financial year is 550 000 tons (TPT OPCO, 2017).

### 4.3.1 Vessel observations performance

A sample study of 64 observations were conducted and recorded on the vessel export operation during an 8 hour shift for bulk manganese. Once the vessel has berthed along the quayside, the vessel loading operation process commences according to plan. Figure 4.5 below illustrates the process of the export operation of bulk manganese from stockpile to vessel and the activities are fragmented into key elements.

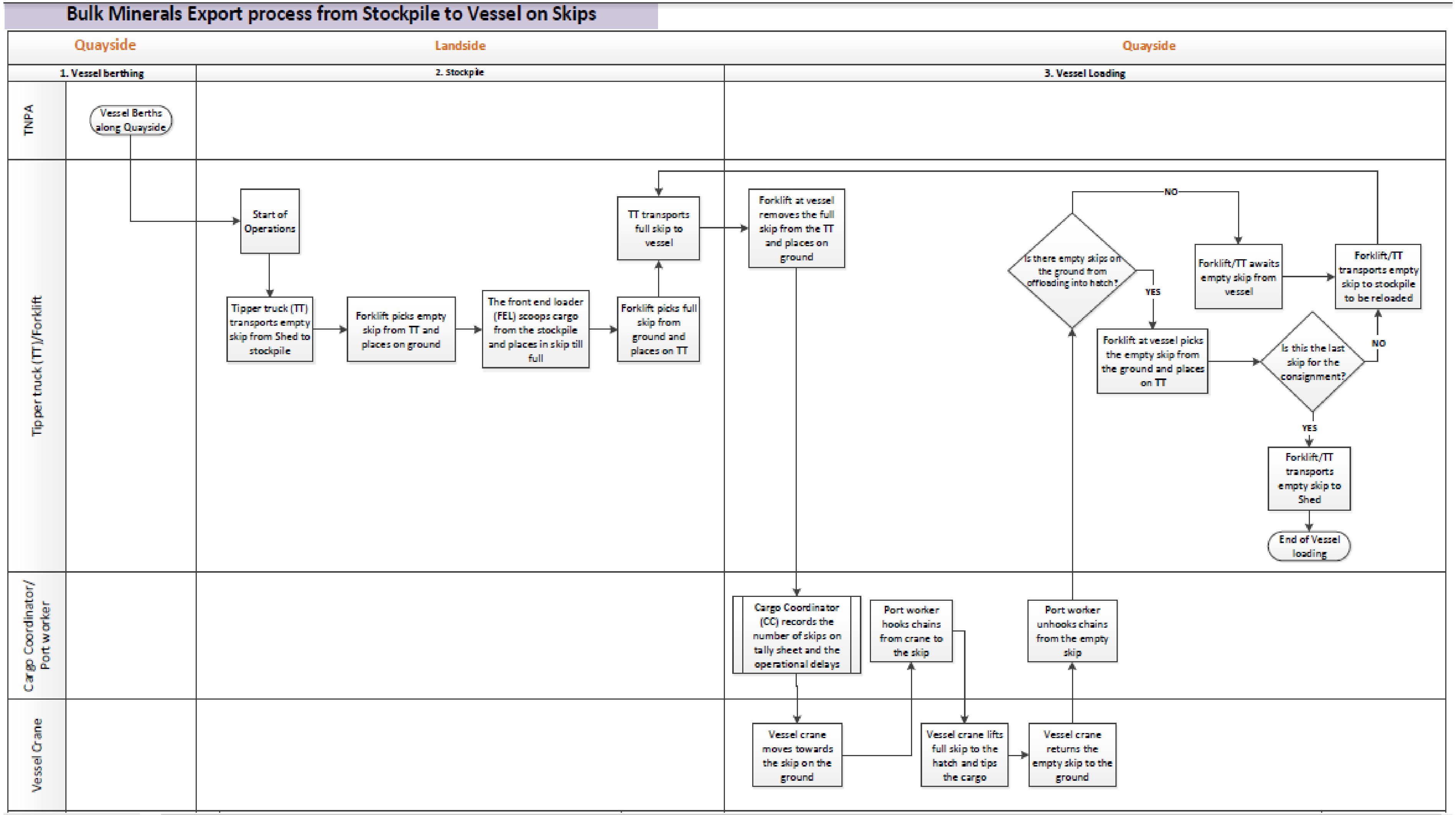


Figure 4.5 Business process map of bulk manganese export operation – Stockpile to Vessel

Source: Author created from direct operational observation at Maydon Wharf terminal – TPT CI (2017)

From figure 4.5, key activities were observed during the study to determine the cycle times of each element through the number of samples observed. The key activities were:

- Tipper truck queuing time at stockpile with skips to be loaded
- Loading full skips onto tipper truck
- Tipper truck travel time to vessel at quayside
- Offload full skip from tipper truck and place on Quayside
- Load empty skip from Quayside onto tipper truck
- Vessel crane hooking of skip
- Vessel crane swing from ground to vessel hatch and tipping skip
- Vessel crane unhooking of skip

The cycle time for each activity was calculated by dividing the total time per activity by the number of observations, resulting in a total cycle time of 12:52 minutes per skip as illustrated in figure 4.6 below:

| Bulk Manganese Vessel operation process chart | Cycle time (Min) | Operation | Transport | Delay | Inspection | Storage |
|---|---|---|---|---|---|---|
| **Process Element Description** | | | | | | |
| Tipper truck queuing time at stockpile with skips to be loaded | 01:22 | | | ● | | |
| Loading full skips onto tipper truck | 01:48 | ● | | | | |
| Tipper truck travel time to vessel at quayside | 01:23 | | ● | | | |
| Offload full skip from tipper truck and place on Quayside | 01:38 | ● | | | | |
| Load empty skip from Quayside onto tipper truck | 01:46 | ● | | | | |
| Vessel crane hooking of skip | 00:40 | ● | | | | |
| Vessel crane swing from ground to vessel hatch and tipping skip | 04:00 | ● | | | | |
| Vessel crane unhooking of skip | 00:15 | ● | | | | |
| **Total Cycle Time per Skip** | **12:52** | **10:07** | **01:23** | **01:22** | | |

Figure 4.6 Bulk Manganese - Vessel operation activity process chart

Source: Author compiled from direct observation of vessel operation – TPT CI (2017)

The bulk manganese VTAT KPI is illustrated in figure 4.7 and the SWH KPI is shown in figure 4.8 below for the 2017/2018 financial year.

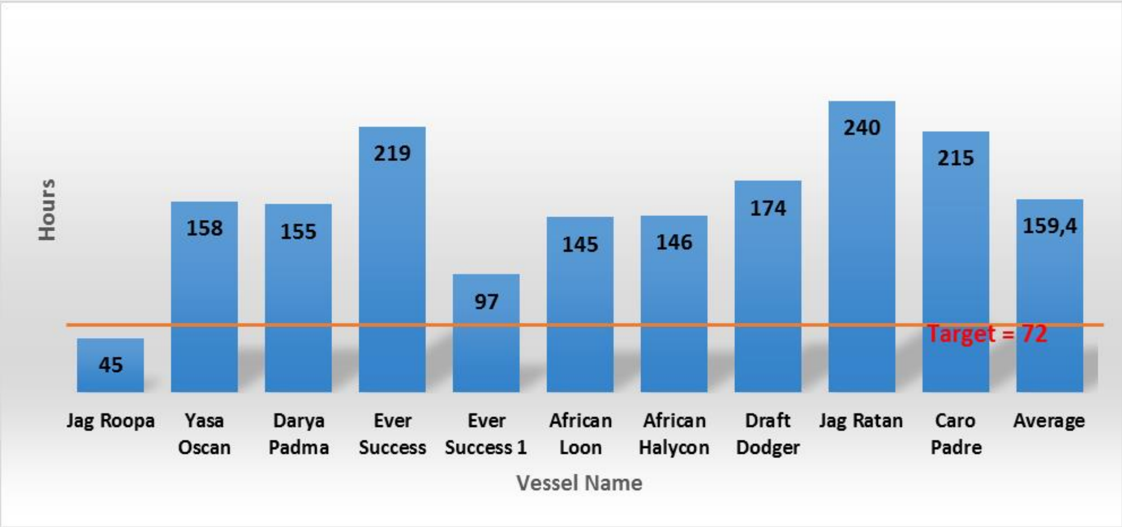


Figure 4.7 Manganese Vessel Turnaround Time by vessel

Source: Author compiled and analysed from TPT MIS Vessel report (2017)

Figure 4.7 illustrates the actual VTAT which is computed on an average per vessel. Data was collected for each vessel from April 2017 till August 2017. The design standard time (target) for VTAT was calculated as 72 hours which equates to 3 days. From the data collected, the actual average VTAT was calculated to be 159,4 hours over a period of 5 months. The VTAT performance is poor when compared to the design time of 72 hours, which means that the target was not achieved by 121%.

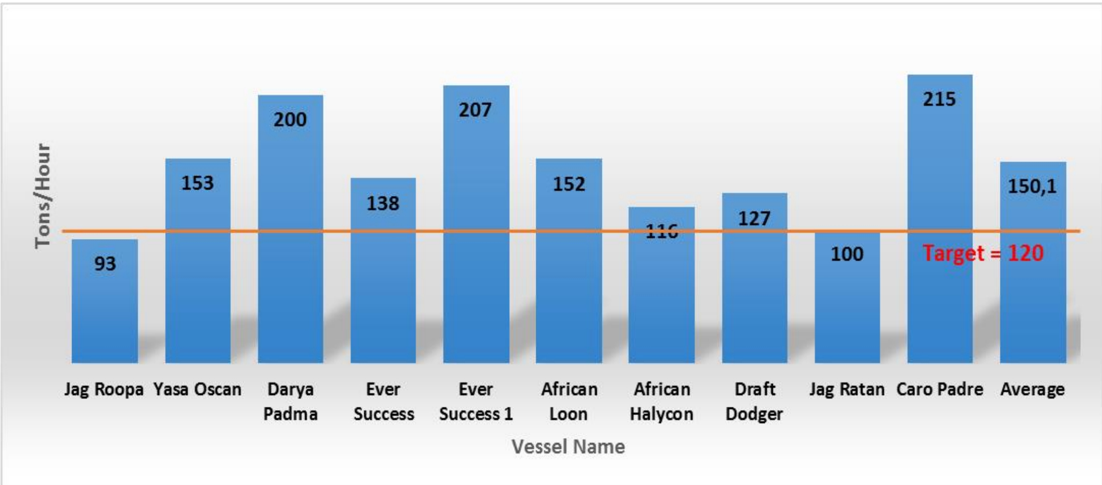


Figure 4.8 Manganese Vessel handling rate (throughput) by vessel

Source: Author compiled and analysed from TPT MIS Vessel report (2017)

Figure 4.8 illustrates the actual handling rate or SWH which is computed on an average for each vessel starting from April to August 2017. SWH is also commonly known as the vessels handling rate or throughput, is measured in tons per hour (TPH). The design standard handling rate (target) for throughput was calculated as 120 TPH. From the data collected, the actual average throughput was calculated to be 150 TPH over a period of 5 months. Manganese operational performance based on throughput displays an exceptional performance with the actual performance rate exceeding the target by 25,1%.

### 4.3.2 Rail Observations Performance

Bulk Manganese is transported from inland mines on Half Height Containers (HHC) to the terminal on rail wagons by TFR. The HHC's carrying the cargo are discharged from the rail wagons, placed on tipping trailers and offloaded onto a stockpile. A train consists of 50 wagons and each wagon contains 2 HHC's. Cargo is exported from the stockpiles within the terminal to vessels that berth along the quayside.

A direct operational observation was conducted on a consignment of 50 wagons to study the operational performance and determine the cycle time per activity.
Key activities were observed during the study on placement of wagons in the terminal to determine the cycle times of each element through the number of samples observed. The key activities were:

- Reach stacker offloads the full HHC from the wagon and places onto tipper truck;
- Tipper truck travels to stockpile;
- Port worker opens HHC doors;
- Tipper truck tips off cargo into stockpile;
- Port worker closes HHC doors and cable ties doors;
- Tipper truck travels to wagon operation area;
- Hauler queues at operation area;
- Reach stacker removes empty container from tipper truck and places onto wagon.

The cycle time for each activity was calculated by dividing the total time per activity by the number of observations, resulting in a total cycle time of 12:58 minutes per HHC as illustrated in figure 4.9 below:

| Bulk Manganese HHC Rail operation Activity process chart | Cycle time (Min) | Operation | Transport | Delay | Inspection | Storage |
|---|---|---|---|---|---|---|
| **Process Element Description** | | | | | | |
| Reach stacker offloads full HHC from wagon and places onto tipper truck | 03:05 | ● | | | | |
| Tipper truck travels to stockpile | 01:00 | | ● | | | |
| Portworker opens HHC doors | 01:30 | ● | | | | |
| Tipper truck tips off cargo into stockpile | 01:08 | ● | | | | |
| Portworker closes HHC doors and cable ties doors | 01:15 | ● | | | | |
| Tipper truck travels to wagon operation area | 01:00 | | ● | | | |
| Hauler queuing at operation area | 02:00 | | | ● | | |
| Reach stacker removes empty container from tipper truck and places onto wagon | 02:00 | ● | | | | |
| **Total Cycle Time per HHC** | **12:58** | **08:58** | **02:00** | **02:00** | - | - |

Figure 4.9 HHC Rail operation activity process chart

Source: Author compiled from direct observation of vessel operation – TPT CI (2017)

The performance of the rail discharge operation is illustrated in table 4.1 below.

Table 4.1 Performance of Rail Turnaround Time

| **Rail Turnaround Time - without delays** | **Quantity** |
|---|---|
| Available operation time (min)/Shift | 720 |
| TPT Internal Shunt time (min) of wagons | 84 |
| Deductable allowances (min) | -105 |
| Available operational time/Shift (min) | 531 |
| Tipper truck turnaround time/HHC (min) | 12.58 |
| Number of wagons/Hour with 2 x tipper trucks | 4 |
| Number of Hours to complete 50 Wagons | 12,5 |

Source: Author compiled and analysed from direct observation of Rail operation – TPT CI (2017)

In table 4.1 above, the RTT was calculated to be 12,5 hours per 50 wagon consignment excluding unplanned delays with 2 tipper trucks. This was calculated by deducting the planned operational delays which are unavoidable, from the total available operation time, which results in the actual available operation time of 531 minutes. 4 wagons with 8 HHC's will be discharged in an hour, therefore it will take 12,5 hours to discharge a consignment of 50 wagons. The RTT design target was calculated to be 12 hours, therefore the actual performance of the manganese RTT on HHC's is slightly underachieving by 4,2%.

## 4.4 Limitations that hinder the required Operational Performance

Key contributors to operational performance targets not being achieved are operational delays and inadequate resources. Some of the delays experienced in a consignment of rail operations are displayed in figure 4.10 below:

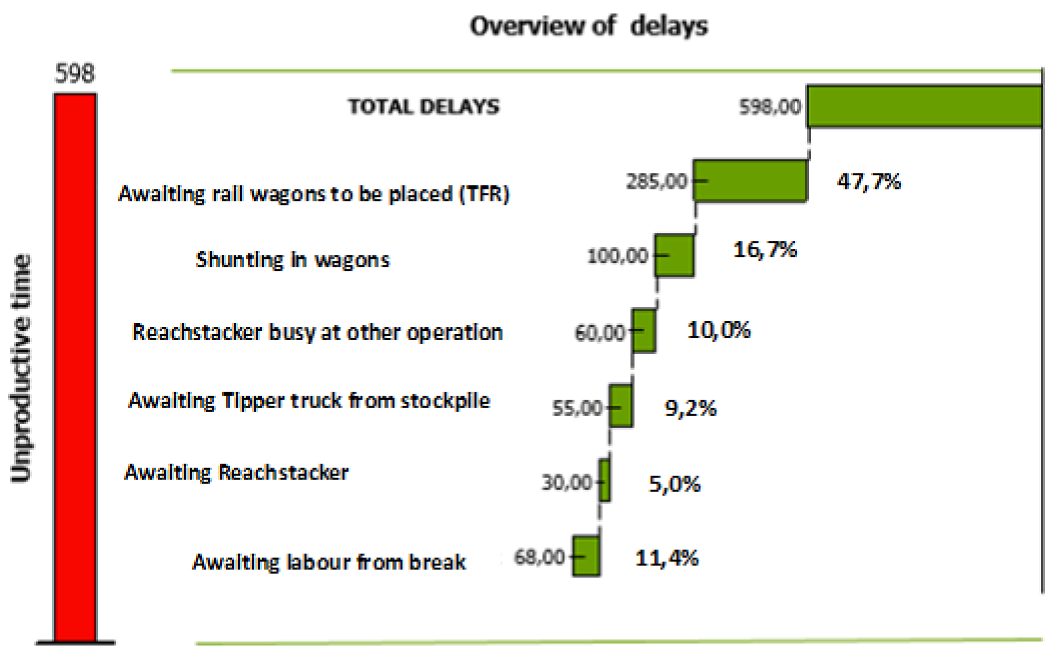


Figure 4.10 Rail discharge delays

Source: Author created and analysed from direct observation of Rail operation – TPT CI (2017)

598 minutes which equates to 9,97 hours of the total operational delays in a consignment of bulk manganese on rail was experienced. The major delays as illustrated in figure 4.10 above. Awaiting for labour from break refers to operational labour that take longer lunchbreaks, additional to the 30 minutes allocated to them during their shift which equated to 68 minutes additional during the consignment studied. Awaiting Reachstacker and Reachstacker busy at another operation refers to the equipment being utilized at another operational activity due to inadequate resources resulting in sharing of equipment. Awaiting tipper truck from stockpile refers to some issues experienced at the stockpile and therefore causing delays to the tipper truck. Shunting inn wagons and awaiting wagons to be placed, refers to TFR taking lengthy time to place the full wagons to be discharged due to challenges on TFR's side. The various delays which form part of unproductive time, contributed to limitations in achieving the required rail operational performance targets as illustrated in figure 4.10 above.

## 4.5 Discussion of research findings

According to Womack & Jones (1990), lean principles can transform terminals operational processes in such a way that it utilizes a partial amount of its initial resources. Other benefits include improved operational efficiency, reduced turnaround times, decrease in costs, value-added services and improved productivity.

In this chapter, the results from the findings were presented and the key performance indicators influencing bulk and break-bulk terminals efficiency was assessed. The analysis of the results focused on theories and observed studies that have contributed towards developing indicators that influence bulk and break-bulk terminals efficiency. Ports are fundamentally providers of service activities. According to Ashar (1995), the level of contentment that is acquired on the basis of predetermined standards will indicate the degree of Port performance attained. Port performance cannot be evaluated on the base of a single measure, a realistic evaluation of Port performance requires a number of measures and therefore the key indicators analysed in this study were: Vessel turnaround time, SWH, TTT, RTT, throughput and cargo dwell time.

According to the results, the overall VTAT performance was poor as the design target was not achieved by 91,6%. The overall SWH was not achieved by 8,3% of the design target which also a poor performance. The TTT overall performance proved to exceed the design target by 5,7% and the overall monthly average cargo dwell time under achieved by 54,2% of the design target.

A further study was conducted purely on the bulk manganese pit to port export operation. This study involved the measurement of operational cycle times, operational performance per vessel, operational rail performance and statistical regression and correlation analysis of throughput and cargo dwell times. According to the results from the study, the VTAT performance on the manganese export operation was poor as the design target was not achieved by 121% and the SWH performance achieved the design target and was exceeded by 25,1%. The manganese RTT displayed a slight underperformance as it underachieved the design target of 12 hours by 4,2%.

From the results of overall Port performance and direct observations of the bulk manganese operation, there are many underlying factors that have a major contribution to the overall poor performance. Such factors are associated with delays in unproductive time as seen in chapter four, amounting to 9.97 hours. These delays attribute to time lost in waiting for equipment, inadequate resources available, waiting for rail wagons to be shunted inn and placed at the operation area, wasted time in shift change over and labour taking longer breaks, unnecessary movement, weather delays, awaiting instructions, unskilled operators, equipment breakdowns, and so forth.

## 4.6 Summary

The purpose of this chapter is to present and analyse the data collected from the direct observations conducted in operations as well as secondary data obtained, in order to determine the current operational performance levels and establish an understanding of the limitations that hinder the required operational performance. Direct observations were conducted and secondary data was obtained to thoroughly measure and analyse the overall operational efficiencies at the bulk and break-bulk terminals at the Port of Durban. The key performance indicators: VTAT, SWH (throughput/handling rate), RTT, TTT and Cargo dwell time; amongst the 3 modes of transport were measured and analysed over the organization's 2017/2018 financial year from April to October 2017.

According to the results of the overall monthly average VTAT performance, it can be concluded that increasing the SWH rate can reduce the VTAT as a key performance indicator in the port. From the above results, the study concludes that the lack of adequate resources, cargo dwell time, vessels/truck/rail turnaround time, cargo handling rate, infrastructure, capacity and operational delays, influence the bulk and break-bulk terminals operational efficiency.

As a result of the discussion in this chapter, the conclusion of the findings will be discussed in chapter 5 and recommendations will be discussed.

# CHAPTER FIVE

# CONCLUSIONS AND RECOMMENDATIONS

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## 5.1 Introduction

This chapter seeks to provide conclusions acquired from the research conducted, the data gathered, processed and analysed in the preceding chapters. The fundamentals of this study was a Lean approach to enhance operational efficiency at the Bulk and Break-bulk terminals in the Port of Durban. Research was conducted through analysis of secondary data based on operational performance at the bulk and break-bulk terminals and was obtained from TPT's MIS department. Further to the analysis, direct observations were conducted on the material handling process of bulk manganese within the terminal, to establish current operational performances. The data obtained was analysed and findings were presented and discussed in the preceding chapters of this study.

## 5.2 Summary of Results

This study makes a contribution in many ways. It analysed and establishes overall port performance and bulk manganese operational performance in line with key performance measures at the bulk and break-bulk terminals at the Port of Durban. Business process mapping and process activity tools were used to identify wastes, non-value adding activities and establish standard cycle times per activity. Lastly, the use of a lean framework is recommended to key stakeholders at the bulk and break-bulk terminals at the Port of Durban to be implemented in mitigating challenges experienced which should result in improved operational efficiency.

More specifically, this research made a contribution to the objectives of the study as follows.

### 5.2.1 Objective One

The first objective of the research was to examine from literature the lean principles that can be implemented to improve efficiency in a bulk and break-bulk terminal environment. The lean approach at Port terminals comprises of established principles that drives the organization to constantly add value to the operational processes. The application of lean in operations enables improvements of required steps in processes and excludes activities within the process that fail to add value, thus enhancing the flow of activities and operational efficiency. Enhancing the operational performance and efficiency of the bulk and break-bulk terminals not only contributes to the profitability of the organization but also has flow-on benefits for relevant stakeholders, internal and external customers, clients and the surrounding environment (Rodrigue & Notteboom, 2009).

There are significant benefits to implementing a lean approach to enhance the operational efficiency at Port terminals, such as: the reduction of operational turnaround times (especially VTAT, TTT & RTT) , time is a major contributor of waste and drives additional excessive operational costs; increase in operational productivity; reduction of cargo dwell times; improved quality (by reducing the number of errors); simplified value added processes; standardization of processes and optimal resource allocation in operations.

According to Song & Panayides (2008), a lean approach makes operational performances visible, to swiftly respond to situations that require corrective actions when required and to transform the organizational culture towards continuous improvement, therefore enhancing the value offered to customers as a key concern.

### 5.2.2 Objective Two

The second objective was to analyse the current operational performance levels at the Bulk and Break-Bulk terminals at the Port of Durban. Results from the findings were calculated over a period of 7 months - April to October 2017 of the current financial year and are presented in table 5.1 below.

Table 5.1 Summary of key indicators results on bulk and break-bulk performance

| Indicator | Monthly Average | Target | Variance | Status |
|---|---|---|---|---|
| VTAT (Hours) | 138 | 72 | -91,6% | |
| SWH (TPH) | 110 | 120 | -8,3% | |
| TTT (minutes) | 33 | 35 | 5,7% | |
| Cargo Dwell time (Hours) | 111 | 72 | -54,2% | |

From the indicators measured, the VTAT results display a monthly average that is 91,6% below achieving the target of 72 hours, SWH is 8,3% below achieving the target of 120 TPH, TTT exceeds the target by 5,7% of the target of 35 minutes and cargo dwell time was calculated as 54,2% below achieving the target of 72 hours. The results of the performance indicators reveal an underperformance of the VTAT, SWH and cargo dwell time, whilst TTT has achieved and exceeded the target.

### 5.2.3 Objective Three

The third objective was to study the material handling operations of bulk manganese through direct operational observations at the Bulk and Break-bulk terminals at the Port of Durban. Results from the direct observation findings were calculated over a 10 vessels for the VTAT and SWH. A sample of 64 observations were conducted on a consignment of manganese for the RTT. The results are presented in table 5.2 below.

Table 5.2 Summary of results of bulk manganese operational performance

| Indicator | Average per consignment | Target | Variance | Status |
|---|---|---|---|---|
| VTAT (Hours) | 159,4 | 72 | -121% | |
| SWH (tons/hr) | 150,1 | 120 | 25,1% | |
| RTT (Hours) | 12,5 | 12 | -4,2% | |

From the indicators measured, the VTAT results display an average of 121% below achieving the target of 72 hours from 10 vessels studied, SWH exceeded the target of 120 TPH by 25,1% and RTT was 4,2% below achieving the target of 12 hours. The results of the manganese operation reveal that VTAT and RTT were underperforming, whilst SWH achieved and exceeded the operational performance target.

From the results of overall port performance and direct observations of the bulk manganese operation, there are many underlying factors that have a major contribution to the overall poor performance. Such factors are associated with delays in unproductive time as seen in chapter four, amounting to 9.97 hours. Some of the delays observed attribute to time lost in waiting for equipment (15%), waiting for rail wagons to be shunted inn (47,7%) and placed at the operation area (16,7%), wasted time in shift change over and labour taking longer breaks (11,4%), insufficient stockpile capacity (9,2%), whilst others were: inadequate resources available, unnecessary movement, weather delays, awaiting instructions, unskilled operators and equipment breakdowns.

## 5.3 Recommendations to Implement Lean at the Bulk and Break-bulk terminals in the Port of Durban

The purpose of the recommendations made is to advise key stakeholders at TPT bulk and break-bulk terminals at the Port of Durban, solutions that will support and enhance operational efficiencies which can be implemented at the material handling operations of bulk and break-bulk cargo to remain competitive and to improve on the services offered.

The following recommendations were made in line with the findings identified during the research.

Through the review of the literature in chapter 2 regarding lean philosophies and operational efficiencies at bulk and break-bulk terminals, the use of the lean framework is recommended to facilitate and implement a lean approach at the bulk and break-bulk terminals at the Port of Durban.

It is recommended that the lean framework be implemented at the Bulk and break-bulk terminals to enable the terminal operator to achieve and enhance operational efficiency. By introducing a culture of continuous improvement, through training labour in techniques of effective problem solving, the terminal can be assured in gaining and enhancing its operational performance in terms of reducing and eliminating waste, improving the operational turnaround times to achieve and exceed targets, improve cargo dwell times and cycle times of activities within a process and improved customer satisfaction levels.

The lean framework discussed in chapter 2.4 of the literature review is recommended to address some of the operational delays recognised during the observational study of the bulk manganese operations. Lean concepts identified in the lean framework was recommended to address the challenges established during the observation conducted which is displayed in table 5.3.

Table: 5.3 Recommendation of the Lean concept to address operational delays

| ***Description of delay*** | ***Delay time (mins.)*** | ***% of Total delays*** | ***Lean concept*** |
|---|---|---|---|
| Awaiting rail wagons to be placed | 285 | 47,7 | Eliminate waste |
| Shunting in wagons (internal) | 100 | 16,7 | Eliminate waste |
| Awaiting operational equipment | 90 | 15 | Levelling |
| Awaiting labour from breaks | 68 | 11,4 | Eliminate waste |
| Awaiting transport equipment | 55 | 9,2 | Standardize |

Awaiting rail wagons to be placed, shunting in wagons and awaiting labour from breaks, requires the elimination of waste to address these delays in order to improve the operational efficiency. Awaiting rail wagons to be placed is the responsibility of TFR operations. It is recommended that a lean event through partnering be conducted between TFR and TPT. The lean event will gather key stakeholders from both operating divisions to identify opportunities of waste, map the business process to identify bottlenecks and establish action plans to address the bottlenecks.

Awaiting labour from breaks, requires the elimination of waste to make the operation more productive. A staggered lunch break is recommended so that all labour does not go on break at the same time and operations can still continue. Awareness in communicating with labour on the impacts of lengthy breaks is recommended. Visualization is also recommended as a key element of the lean concept to be effectively incorporated into the terminals implementation of the lean framework. Work procedures, instructions, targets such as hourly scores should be made visible and always be updated; this supports the operational workforce to be more aware of time wasted. Inconsistencies and deviations from standard targets are instantly noticeable.

Awaiting operational equipment requires the concept of levelling to address the challenge experienced. There is currently insufficient material handling equipment and therefore requires sharing of resources with other operations occurring in parallel. This results in waiting time for equipment to return to its planned operation. Levelling is recommended as it will improve coordination and effective planning of resources such as material handling equipment.

Awaiting transport equipment from stockpile is experienced due to a capacity constraint within the terminal. Levelling is applied in lean operations within the port environment to address the variability in the flow of cargo and to have a coordinated operational process. Therefore, it is recommended that levelling be implemented within bulk and break-bulk operations to create a more balanced working schedule and making optimal use of the terminal capacity to plan stockpiles according to the work-load and demand of capacity required

## 5.4 Limitations of the Study

There were challenges that were experienced by the observers during the study such as the long hours required due to the operational process being a 24 hour operation. Labour at times were not forthcoming with information required even though they were aware of the study being conducted. Weather challenges were experienced due to the operation being in an outside open area. Data recorded during the study was not clear in few instances and those observations were eliminated. There is also a lack of information and published studies regarding operational performances within the bulk and break-bulk Ports of South Africa.

## 5.5 Recommendations for Future Studies

The current study explored the lean approach to enhance operational performance of bulk and break-bulk material handling in port operations, this study has not explored the importance of extending a lean approach to customer-oriented components and activities from other key departments (planning, engineering, procurement, finance, ICT) within the bulk and break-bulk terminals to recognise the full potential of lean within the entire organization. A lean approach to customer-oriented components makes for an interesting opportunity for future research. In order for the lean approach to be effective across the supply chain, inclusion of customer-oriented components and activities from other key departments are essential in increasing the probability of creating value across the entire organization; leading to innovative opportunities. The element of the customer perspective is often overlooked as ports strive to improve their operational performance. Operational performance require the support of the other departments within the organization as they are all interrelated. This proposal of future research can also provide further theoretical contributions to science since research concerning lean on customer's perception is limited.

A study on the perspective of operational labour to implement lean in improving operational performance at the bulk and break-bulk terminal environment will also make an interesting study for future research as most of the activities and processes within operations are experienced first-hand with operational labour. Lastly, testing and implementing the recommendations of this study will also be of interest for future research.

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# Appendix 1: Ethical clearance

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

17 October 2017

**Ms Deviakumarie Naicker (200301081)**
**Graduate School of Business & Leadership**
**Westville Campus**

Dear Ms Naicker,

**Protocol reference number: HSS/1729/017M**
**Project title:** A lean approach to enhance operational efficiency at the Bult and Break-Bulk Terminals at the Port of Durban

**Approval Notification – Expedited Approval**

In response to your application received on 13 September 2017, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

**Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.**

**PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.**

**The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.**

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

[redacted]

**Dr Shenuka Singh (Chair)**

**/ms**

Cc Supervisor: Dr Mihalis Chasomeris
Cc Academic Leader Research: Dr Muhammad Hoque
Cc School Administrator: Ms Zarina Bullyraj

## Appendix 2: Turnitin Report Summary

Turnitin Originality Report

MBA Dissertation - 200301081 by Divya Naicker

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