UNIVERSITY OF KWAZULU-NATAL

AN ASSESSMENT OF PORT PRODUCTIVITY AT SOUTH AFRICAN CONTAINER PORT TERMINALS

by

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DECLARATION

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LIST OF ABBREVIATIONS

CSP	Container stowage problem
CTCT	Cape Town Container Terminal
CTOC	Container terminal operations contract
DCT	Durban Container Terminal
GCH	Gross crane hour
GDP	Gross domestic product
GRT	Gross registered ton
ICS	International Chamber of Shipping
IMDG	International Maritime Dangerous Goods
KPI	Key performance indicators
MAS	Multi agent systems
NCT	Ngqura Container Terminal
OECD	Organisation for Economic Cooperation and Development
RTG	Rubber-tyred gantries
SAGT	South Asian Gateway Terminal
SAMSA	South African Maritime Safety Authority
STS	Ship to shore
STAT	Ship turnaround time
SWH	Ship working hour
TEU	Twenty-foot equivalent unit
TNPA	Transnet National Ports Authority
TPTA	Total port turnaround time
TPT	Transnet Ports Terminal
UCT	Unity container terminal
UNCTAD	United Nation Conference on Trade and Development
VLCS	Very large container ships

ABSTRACT

The increasing intermodal sophistication and globalisation of the international container shipping industry, as well as increased competition on container throughput between major ports, requires container terminals to continuously improve their efficiency in relation to productivity and performance. This dissertation seeks to examine and analyse productivity data over a period of time, in order to determine port productivity trends at three main container terminals in South Africa. Given the existing infrastructure and available resources at the container port terminals, the research further analyses the gaps between expected or targeted performance against actual productivity trends to date. It further tests current performance levels against international benchmarks and makes recommendation on productivity optimisation and best practice. This study is motivated by the rapid development and a dire need in container terminal port operations to provide efficient and effective services as well as high port productivity. In South Africa, port productivity is still seen as suboptimal in global terms and it is for this reason that South African container terminals continue to seek improvement in achieving quicker port turnaround times. The literature review highlights thoughts and opinions on previous research as far as the formula for efficient and effective port productivity is concerned. When measuring port productivity, a number of factors need strategic integrations and a balanced approach. These include ship turnaround times, port superstructure performance, stowage plans, labour dynamics, information flow between various stakeholders, yard management and cost of operations. This research identifies crane performance and ship work-rate performance as the major indicators of productivity at the respective terminals. In the South African port terminals context, these two indicators were lower than targeted for. This is due to a number of reasons including lack of the full utilization of the current crane regime, equipment downtime, poor coordination between the operator and shippers, inefficient landside operations as well as labour inefficiency. This study therefore recommends that the port terminal operator should put the current infrastructure into full utilization, adhere to maintenance schedules of all terminal equipment with improved training regimes within a more skilled labour force. There is a need to enhance landside capacity and layout. This research contends that this would contribute towards shorter port stays and improved vessel turnaround times.

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CHAPTER 1

INTRODUCTION

1.1 Dissertation objectives

The objective of this research dissertation is to examine and analyse productivity data over a period of time, in order to determine the port productivity trends at three main container terminals in South Africa. Given the current existing infrastructure and available resources at the container port terminals, the research will further analyse the gaps between the expected performances against the actual productivity trends to date. Productivity and efficiency at South African container port terminals has proven to be suboptimal to date. This research investigation aims to explore the actual causes of such low and inconsistent performance over time, establish factors which limit expected productivity and propose potential improvement interventions according to global industry best practices together with a benchmarking exercise with similar ports. The contention of this paper is that, with the existing infrastructure and resources at hand, the container terminal productivity and efficiency can be improved to reach optimal levels of performance.

Port productivity and port efficiency are two related but different concepts. Port productivity is usefully defined as the combined measure of results pertaining to available resource utilisation as inputs to be transformed into outputs, while efficiency can be defined as relative productivity necessary to achieve a desired output over a period of time or space (Tioga Group Report, June 2010). Productivity and efficiency are therefore the two most important concepts in measuring port performance, expressing different ranges of parameters and variables, to be further unpacked in this dissertation.

1.2 International sea trade context

Approximately 90 per cent of global merchandise trade by volume is carried by sea and handled by ports worldwide (International Chamber of Shipping: Overview on Shipping and World Trade, 2013). South Africa is one of the major sea trading nations, ranking in the top 15 countries on the basis of seaborne trade tons, and accounts for 5.5 per cent (SAMSA Maritime Economy Outlook, 2013) of 9.6 billion tons, which is the total global international sea trade by volume (UNCTAD, 2014). For a strategically-placed gateway economy such as South Africa, functional and well performing ports are an essential element in ensuring increased economic development and activity.

The importance and significance of optimal port productivity cuts across many different perspectives of the different stakeholders who use container port terminals. For the terminal operator, port productivity is an important measure to monitor and maximise terminal performance, plan capital expenditure and recover project revenue while reducing the cost of doing business. The operator's priority is to service vessels as quickly and as efficiently as possible through deploying adequate equipment, fully utilising the allocated labour, optimally utilising the quay and efficiently operating the landside. The carrier's priority is for the terminal operator to turn the vessels as fast as possible and at the lowest cost, invest in cranes to be able to work vessels of all sizes quickly, control cost by minimising labour and avoid vessel berthing conflict of different shipping lines. The port authority's main goal is to secure maximum vessel calls and attract container volumes, thus requiring higher levels of productivity. The port operator also serves an additional oversight role to all port users in respect of the standards of performance. It is in their interest to maximise the usage of the land in order to positively influence the level of quality of service to be provided by the port user to the end customer. The industry and shippers' perspectives are based on capacity, transit times in relation to the entire supply chain, reliability and cost consistency. In this light, South Africa is not excluded from, nor immune to maintaining global competitive standards in order to attract traffic of ships through its ports and offer efficient port performance, competitive cost of service and well-developed corridors linking ports to major economic hinterland networks.

Considering the extent to which globalisation has intensified, and the ever-growing interdependence of countries around the globe, there has been an increase in the integration of trade, finance, ideas and people, causing international trade to thrive and increase cross-border investment flows. Globalisation has accelerated considerably since the mid-1980s, having been driven mainly by the two pivotal factors of technological advancement and increased liberalisation of trade and capital markets. Technological advancement has served an important role in reducing the cost of doing business by lowering the cost of transportation, communications, and computations allowed for businesses to locate different centres of production in many different countries. Liberalisation on the other hand promoted freer trade between countries, leading governments to reduce trade restrictions and promote freer movement of goods in areas relating to social, political and economic policies. As a result of globalisation, international trade between nations continues to grow, causing more exchanges of goods and services, which in turn affects the movement of the world's economic growth patterns.

The context of this dissertation and its significance cannot be analysed in isolation and will need to be understood from the perspective of the economics of the international maritime transport industry in its entirety. International maritime transport is the key backbone of international trade, which is driven by the world economy. According to Martin Stopford (2009), the world economy is undoubtedly the single influence that generates most of the demand for sea transport, through either the import of raw materials for the manufacturing industry or the trade in manufactured products to different global destinations[1]. According to the supply and demand model, which is a technique used by economists to analyse commodity markets, the world economy is one of the most important factors influencing the model, in that it determines the broad volume of goods traded by sea. Maritime transport is a 'derived demand' in that shipping demand comes about as a result of seaborne trade. The growth of the world economy, through business cycles as well as the trade development cycles, determines its performance.

Business cycles are influenced by the fluctuation of the rate of economic growth or gross domestic product (GDP), which in turn affects seaborne trade, creating cyclical patterns of demand for ships. The cycles in the world economy are mirrored by cycles in sea trade (see Figure 1.1). When the world economy booms, there is more consumption of goods leading to more investments in resources necessary to sustain the economic activity. Conversely, when the economy overheats from increased

[1] Martin Stopford, Maritime Economics 3rd Edition, 2009: Chapter 4, Supply, Demand and Freight Rates – The Demand for Sea Transport, page 140.

demand and resources cannot handle rapid growth, consumption decreases and the growth rate slows down. This affects planned investments on infrastructure and the multiplier effect goes into reverse, hence the mirror effect between the economic growth rate and sea trade. The world economy also affects trade cycles, in that local resources of food and raw materials are required to meet the local demand. However, domestic raw materials tend to get depleted and fall short of local demand, which drives users to turn to foreign supplies, thereby boosting trade or foreign supplies which may be of superior quality to local supplies and cheaper to import, transport-wise.

Global economic growth underperformed in 2013, with the situation in developed economies improving slightly and a number of setbacks constraining economic activity in developing regions. World GDP expanded by 2.3 per cent in 2013, the same rate as for the previous year. The performance across the major country groupings was uneven. Growth in GDP in developed economies accelerated to 1.3 per cent compared with 2012, while it decelerated in developing economies and the economies in transition, as detailed in Table 1.1 below. One major reason for the slower economic growth was the diminishing demand on imports by the matured economies, which had a knock-on effect on developing economies, mainly Asia and Africa. However developing economies grew at a reasonable rate, with some showing a slight deceleration. China, as one example, experienced a deceleration from a 7.7 per cent growth rate in 2013 to 7.5 per cent, because export demand from China weakened, especially for the European markets. Efforts were also made to slow down the rapid pace of China's economic growth in order to manage inflationary pressures. Africa's growth rate also slowed down from 5.3 per cent in 2012 to 3.5 per cent in 2013, for reasons similar to China regarding diminished import demand. However the economy still remained resilient because of increased fiscal spending on infrastructure projects and more Africa–Asia investments as well as trade linkages such as the Brazil Russia India China South Africa (BRICS) bloc.

Table 1.1: World economic growth, 2011–2014 (annual percentage changes)

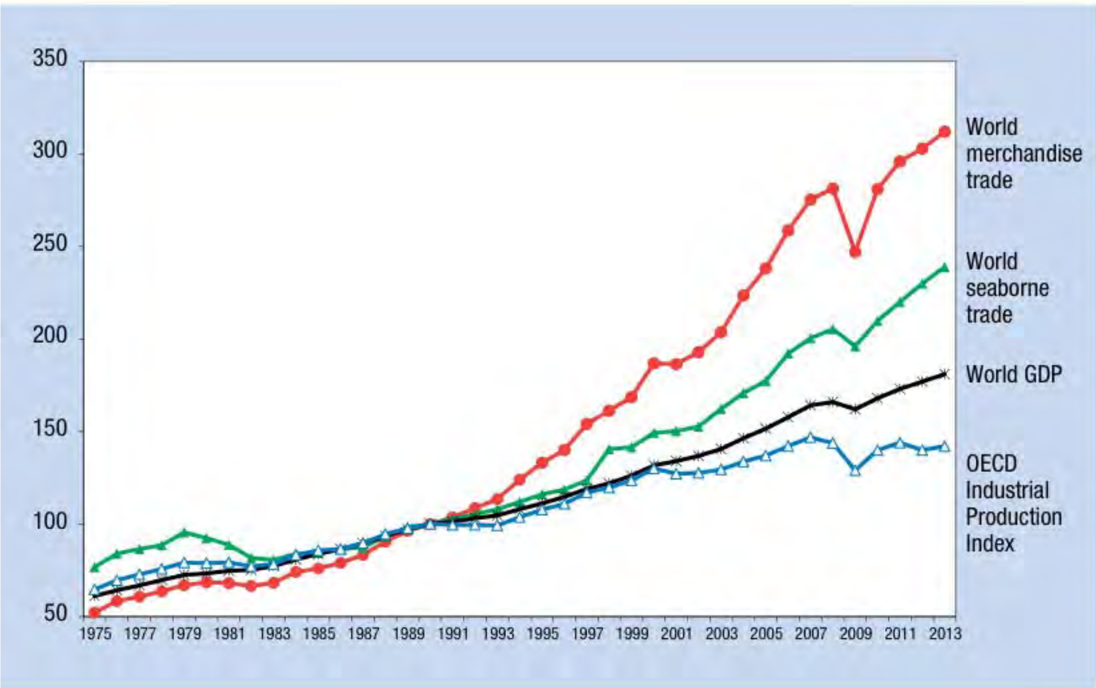
Region/country	2011	2012	2013	2014[a]
WORLD	2.8	2.3	2.3	2.7
Developed economies	1.4	1.1	1.3	1.8
of which:				
European Union 28	1.7	-0.3	0.1	1.6
of which:				
France	2.0	0.0	0.2	0.7
Germany	3.3	0.7	0.4	1.9
Italy	0.4	-2.4	-1.9	0.1
United Kingdom	1.1	0.3	1.7	3.1
Japan	-0.6	1.4	1.6	1.4
United States	1.6	2.3	2.2	2.1
Developing economies	6.0	4.7	4.6	4.7
of which:				
Africa	0.9	5.3	3.5	3.9
South Africa	3.6	2.5	1.9	1.8
Asia	7.2	5.2	5.3	5.6
China	9.3	7.7	7.7	7.5
India	7.9	4.9	4.7	5.6
Western Asia	7.4	3.8	3.8	4.0
Developing America	4.3	3.0	2.6	1.9
Brazil	2.7	1.0	2.5	1.3
Least developed countries	3.6	4.9	5.4	5.7
Transition economies	4.7	3.3	2.0	1.3
of which:				
Russian Federation	4.3	3.4	1.3	0.5

Source: UNCTAD, 2014

In South Africa, the major contributor to the country's GDP comes from the export market. Approximately 58 per cent of GDP comes from trade (SAMSA, 2013). As indicated in Table 1.1, since 2011, South Africa's economy started seeing a declining growth rate from 3.6 per cent in 2011 right down to 2.5 per cent in 2012 and 1.9 per cent in 2013 and 1.39 per cent in 2014 (Trading Economics, 2014). The slow growth is principally the result of weak external demand from South Africa's traditional partners, namely Europe, the United States and Japan, which affected the export market, particularly in manufactured goods. Secondly, growth in exports to China has partially offset reduced trade with advanced economies, but has made South Africa more vulnerable to shifts in Chinese import demand and related commodity price adjustments. However, apart from the economic uncertainties with the major trading partners, South Africa experienced a litany of strikes and power outages in 2014.

Figure 1.1 depicts how the world economic growth rate (in terms of GDP), the world merchandise trade and seaborne trade continue to move in tandem. Since 1990, world seaborne trade has been growing better and faster than the world economy owing to a number of factors. First, the economic structures of countries generating seaborne trade in different regions go through different trade cycles and maturity at different periods. Second, and specifically in 2013, seaborne trade's moderate growth performance was influenced and affected by a number of trends including the balanced growth in trade demand, the continued persistent oversupply in the world fleet across various market segments, high bunker prices, as well as a wider use of slow steaming, especially in the container sector.

Figure 1.1: OECD industrial production index and indices for world gross domestic product, merchandise trade and seaborne shipments (1975–2013)



Source: UNCTAD, 2014

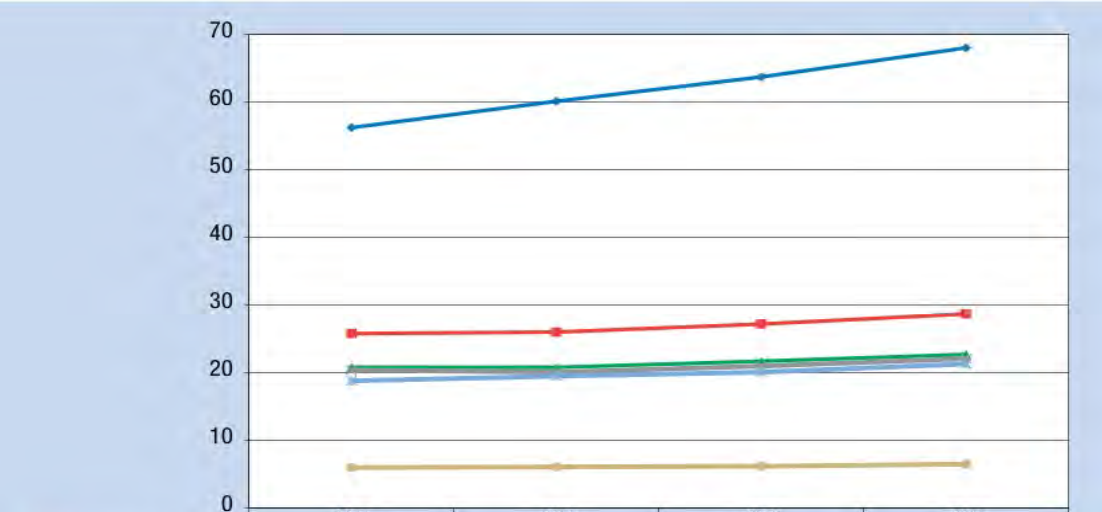
The world container throughput in 2013 – in other words, containers handled at ports including the port of origin, destination and trans-shipments – has increased by an estimated 5.1 per cent and surpassed the 650 million twenty-foot equivalent unit (TEU) mark, from 601.8 million TEUs in 2012 to 651.1 million TEUs in 2013. This increase was in line with a similar increase for 2012, this being 5.4 per cent. The share of port throughput for developing countries increased by an estimated 7.2 per cent in 2013, higher than the 5.2 per cent increase estimated for the previous year. Asian ports continue to dominate the league table for port throughput and terminal efficiency.

The global container trade grew by 4.6 per cent in 2013 taking the total volumes to 160 million TEUs, up from 153 million TEUs in 2012 (refer to Figure 1.3). Each trade route contributed towards the container market growth with the intra-regional and South–South trades topping the list and accounting for 39.8 per cent of the global containerised trade shipments in 2013. The next best performing trade route was North–South trade at 17 per cent, the Transpacific at 13.6 per cent, Far East–Europe at 13.1 per cent, secondary East–West at 12.6 per cent and Transatlantic at 3.9 per cent[2] (see Figure 1.3 below). The containerised trade flow in 2013 was, however, characterised by the following elements:

- Further cascading of larger tonnage down from the main lanes to smaller and secondary routes;
- Greater uptake of slow steaming, which started in 2007 in response to rapid increase in bunker prices with a view to addressing capacity oversupply; and
- Continued efforts to build alliances among ship owners in order to control costs and maximise capacity utilisation on larger ships.

Figure 1.2: Distribution of global containerised trade routes, 2011–2014 (millions of TEUs)

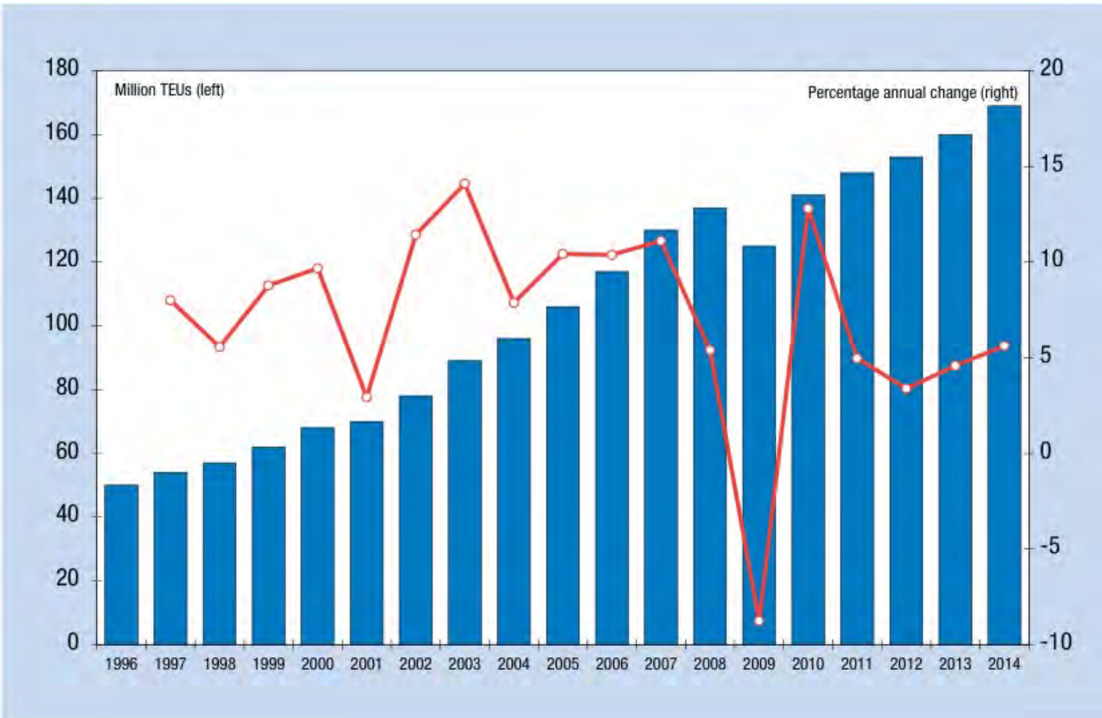
[2] Intra-regional trade is led by intra-Asian trade, the three routes on the Major East–West trade lane, specifically the Transpacific, Asia–Europe and the Transatlantic, bring together three main economic regions, namely Asia (mainly China) and Europe and north America.



	2011	2012	2013	2014
Intraregional & South-South	56.2	60.1	63.7	68.0
North–South	25.8	26.0	27.2	28.7
Trans-Pacific	20.8	20.8	21.7	22.7
Far East-Europe	20.4	20.1	21.0	22.1
Secondary East-West	18.8	19.5	20.1	21.3
Transatlantic	6.0	6.1	6.2	6.5

Source: UNCTAD, 2014

Figure 1.3: Global container trade, 1996–2014 (millions of TEUs and percentage annual change)

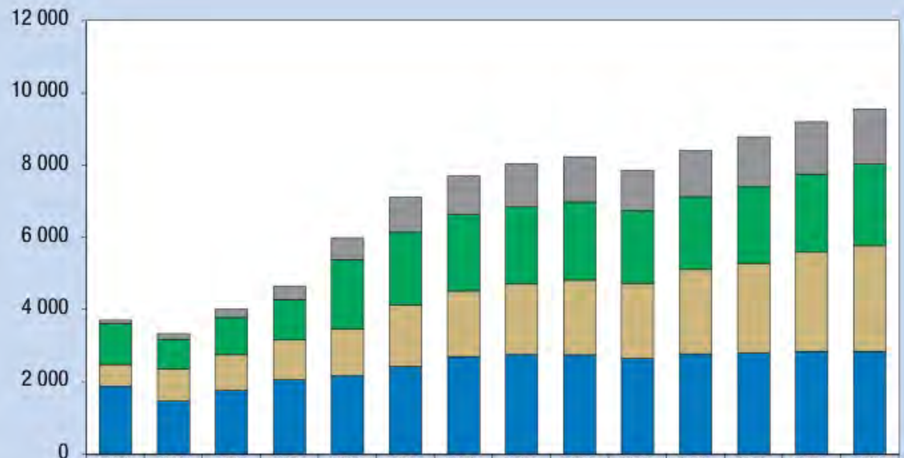


Source: UNCTAD, 2014

Global containerised trade was projected to continue growing in the different trade routes by 5.4 per cent in 2014. With regard to the tonnage outlook, there still exists a severe tonnage glut that is still not expected to diminish soon, regardless of the slight growth in containerised trades. With about 85 per cent of the world's existing order book for container ships to be delivered by the end of 2015, there will be a need to scrap 25 per cent of all container vessels with a capacity of 3 000 TEUs in order to maintain the current demand-supply balance (Murphy, 2014). As carriers deploy ever-larger container vessels, the sheer volume of containers aboard those vessels will have an overwhelming impact on gateway ports, challenging their ability to unload import containers timeously. Alliances will therefore need to be formed in order to fill the ships up, resulting in more pressure being put on the container terminals and on the landside road and rail connections.

In 2013, as indicated in Figure 1.4, dry bulk volumes remained at the core of the dry cargo trades, with the five major bulk volumes (coal, iron ore, grain, bauxite/alumina and phosphate rock) accounting for 44.2 per cent of the total volume of dry cargo and minor bulks making up 21.0 per cent. Containerised trade and general cargo accounted for the remaining share of 35.4 per cent. The five major dry bulks expanded the fastest at the rate of 6.5 per cent, followed by general cargo (4.7%), containers (4.6%), and minor bulks (3.9%). Growth in tanker trade showed diverging trends as crude oil product volumes increased 93.2 per cent and gas trade remained flat. Iron ore and coal, were, however, propelled by strong import demand into Asia (mainly China and India).

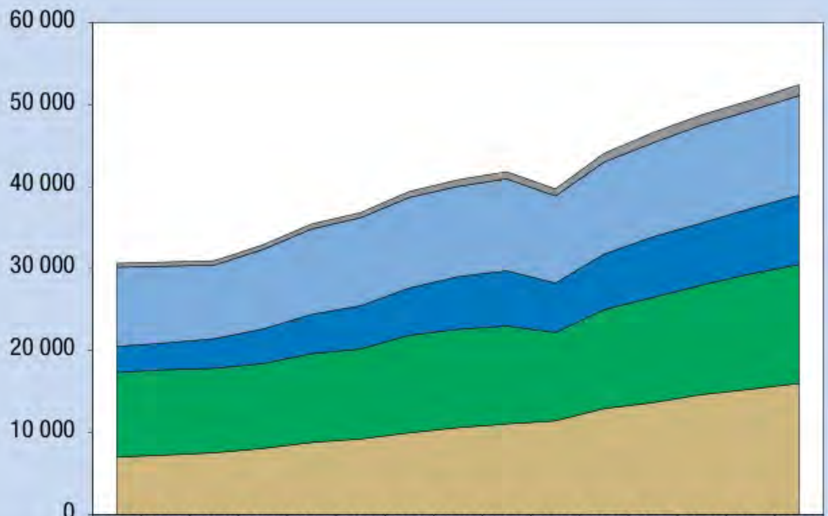
Figure 1.4: General trends in seaborne trade per cargo sector (1980–2013)



	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
Container	102	152	234	371	598	969	1 076	1 193	1 249	1 127	1 280	1 393	1 445	1 524
Other dry cargo	1 123	819	1 031	1 125	1 928	2 009	2 112	2 141	2 173	2 004	2 022	2 112	2 169	2 260
Five major bulks	608	900	988	1 105	1 295	1 709	1 814	1 953	2 065	2 085	2 335	2 486	2 742	2 920
Oil and gas	1 871	1 459	1 755	2 050	2 163	2 422	2 698	2 747	2 742	2 642	2 772	2 794	2 841	2 844

Source: UNCTAD, 2014

Figure 1.5: World seaborne trade in cargo ton-miles by cargo type, 1999–2013 (billions of ton–miles)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Gas	498	509	536	569	610	623	722	807	869	864	1060	1248	1255	1241	1330
Oil	9627	9355	8963	9693	10408	10732	11037	10997	11203	10616	11226	11452	11928	11936	12117
Container	3176	3278	3608	4221	4789	5276	5765	6424	6740	6037	6772	7388	7584	7964	8466
Other (minor bulks & other)	10319	10387	10298	10343	10815	10960	11889	11984	11925	10757	12057	12828	13340	14061	14487
Five main dry bulks	7028	7275	7553	8082	8829	9239	9988	10618	11081	11445	12942	13663	14643	15298	16018

Source: UNCTAD Review of Maritime Transport, 2014

Against this background, seaports still remain the nerve centres of foreign trade. With the forecasted throughput and growth patterns for container trade, ports will need appropriate infrastructure necessary to handle the anticipated future volumes as far as performance and efficiency is concerned. This paper intends to give an overview of the South African ports system and place emphasis on the container port sector, outlining the historical statistics on performance and productivity. Focus will be placed on investigating the maximum capacity of container terminals in South Africa, reasons for substandard performance and on the proposed optimisation framework required to meet the growing demand for sea trade passing through these ports. The assumption will be that the current resource capacity at the three main container terminals (in terms of quay, superstructures, labour and landside) can have higher productivity levels than the actual current performance.

As part of the research process for this dissertation, this introduction will be followed by Chapter 2 with a detailed literature review outlining specific conceptual thoughts put together by industry role players from previously published research, with emphasis on the details of port productivity at container terminals across the globe. The literature addresses different approaches and perspectives for measuring port productivity and efficiency in container terminals. Performance measurements will be looked at based on the entire port's terminal operations on quayside and landside, together with the generally adopted key performance indicators used to measure productivity. This chapter will also point out the implications and benefits of certain measurements approaches applied to container terminals in determining and evaluating performance. Chapter 3 will outline the methodology to be adopted in answering the research question and responding to the underlying hypothesis to be proven. Chapter 4 will present an overview of the South African port system, with the main focus placed on the container sector in its current form. The results of the collected data are presented in Chapter 5, followed by a critical analysis thereof, including a relevant comparative benchmark analysis based on the similar ports selected, looking mainly at the common commercial indicators to be benchmarked. Finally, Chapter 6 will present a conclusion drawn from the results, and recommendations will be proposed on improvement strategies for the container industry.

CHAPTER 2

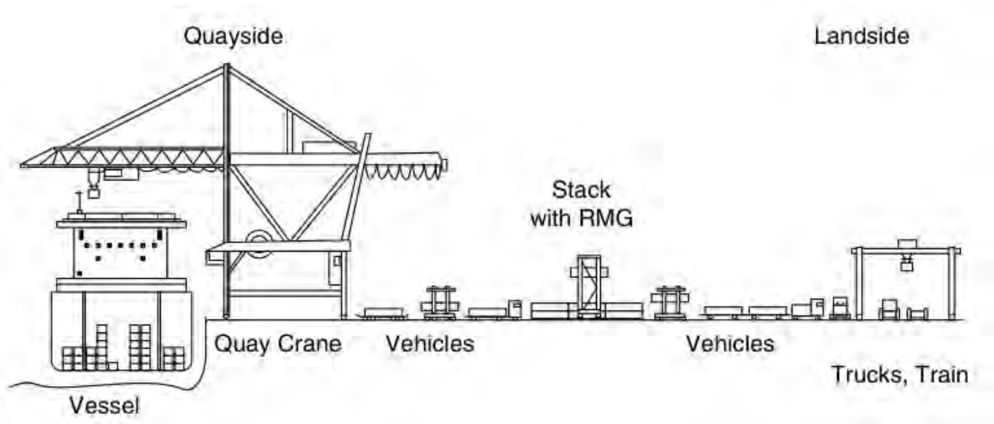
LITERATURE REVIEW

Individual ports have distinctive characteristics, and this distinctiveness makes the measuring and analysis of performance not a very simple task. The industry to date has not established a standard approach for measuring port productivity in a consistent manner, as no single current measure encapsulates all the important aspects of port or terminal performance. The literature review will survey previously written material and opinions from different authors addressing the most commonly used parameters for measuring efficiency at different container terminals, including trans-shipment hubs. In addition, the review will unpack several adopted key performance indicators based on the different functions and configuration of a standard container port terminal as well as commonly used methods of productivity improvements and optimisation. The main reason for the scope of the literature in relation to the dissertation concept is to use best practice and established conceptual approaches and principles to test the impact of the currently used parameters measuring productivity in South African container terminals as well as any related limitations.

2.1 Performance measurement of container terminals

Traditionally, the performance of ports has been measured by looking at various factors such as calculating cargo-handling productivity at berth (Bendall and Stent, 1987; Tabernacle, 1995; Arshar, 1997), measuring single factor productivity (De Monie, 1987), or by comparing actual optimum throughput over a specific period of time (Talley, 1998). Figure 2.1 illustrates the schematic flow of an operation at a container terminal from the point where cargo is discharged, to a point where cargo is loaded onto the next mode of transport into the hinterland.

Figure 2.1: Schematic representation of a container terminal



Source: Steenken et al., 2004

Koh and Ng, 1994, categorise the main activities that make up the whole container port operation, into the following sub-activities:

1. **Berth operation** – the berth operation involves the scheduled arrival of the vessel and resources from wharf space to quay cranes necessary to handle the vessel. The critical objective of the berth operation, as far as productivity is concerned, is to achieve minimum turnaround time of the vessel at the quayside.
2. **Vessel operation** – the vessel operation involves the loading and unloading of cargo on board the vessel handled by quay cranes. The key objective of the vessel operation is to achieve maximum number of containers moved per hour.
3. **Yard operation** – yard operation involves the discharge of containers from the vessel, loading of containers on board the vessel using different types of yard vehicles including straddle carriers or rubber-tyred gantries (RTG), re-stowing of containers that are out of sequence and distribution of containers for trans-shipment purposes. The objective of the optimal yard operations is to ensure seamless yard fluidity through efficient landside management and hinterland connectivity, thereby reducing container dwell time and also allowing enough space for new containers entering the port.
4. **Gate operation** – gate operations involve the management of a point whereby container delivery from freight forwarders to be loaded onto the vessel takes

place and serves as an exit point for received import containers from the yard into the hinterland.

Understanding the characteristics of a container terminal together with its layout is critical in determining the correct parameters needed to measure port performance, based on various aspects of the port's operation. In 1976, UNCTAD suggested two broad categories of port key performance indicators (KPI) – namely operational and financial indicators – which have been widely used as a reference point by many container terminals worldwide (Marlow and Casaca, 2003). These are detailed in Table 2.1 below.

Table 2.1: Summary of performance indicators suggested by UNCTAD (1975)

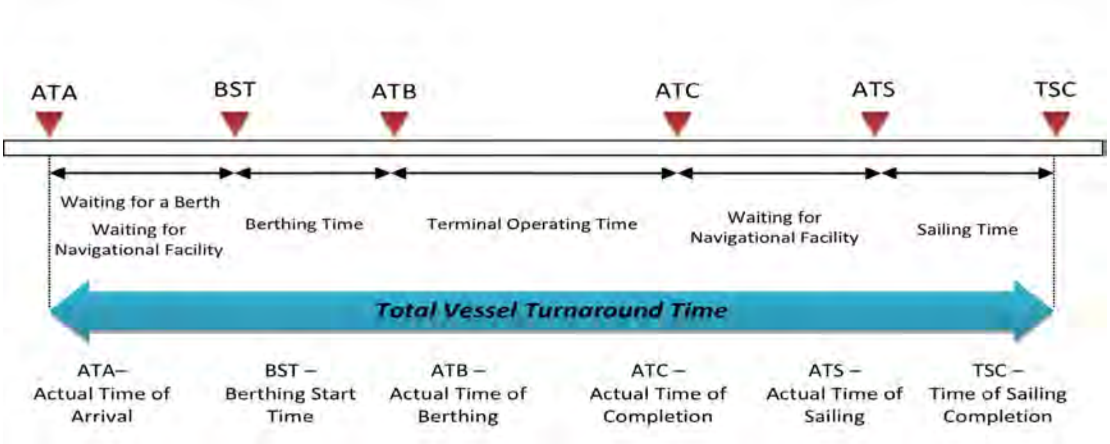
Financial indicators	Operational indicators
Tonnage worked	Arrival time
Berth occupancy revenue per ton of cargo	Waiting time
Cargo handling revenue per ton of cargo	Service time
Labour expenditure	Turnaround time
Capital equipment expenditure per ton of cargo	Tonnage per ship
Contribution per ton of cargo	Fraction of time berthed ships worked
	Number of gangs employed per ship per shift
	Tons per ship hour in port
	Tons per ship hour at berth
	Tons per gang hour
	Fractions per time gang idle

Source: UNCTAD, 1975

For the purposes of this dissertation, emphasis will be placed on the operational KPIs, which cover a broader range of parameters from the time the vessel enters the port to the point where it is fully loaded and leaves the port.

In the UNCTAD monograph on measuring and evaluating port performance and productivity, De Monie (1987) suggests that a meaningful evaluation of a port's performance could not be made on a basis of one single measure. A meaningful measure of performance requires sets of measures relating to the duration of a ship's stay in port, the quality of the cargo handling as well as the quality of service to inland transport vehicles during their passage through the port. For the purpose of this dissertation, we will focus on the first two measures. The ship's stay in port refers to the total vessel turnaround time, which De Monie regards as the first and foremost measure of vessel productivity through a port. The total vessel turnaround time can be broken down into periods, starting from the point where the vessel is in port waiting for a berth until it has completed loading and leaves the port.

Figure 2.2: Particulars included in total vessel turnaround time



Source: Ashan Shanthirathne, 2013

Reduction of any of the above periods will certainly improve productivity of the vessel in port, particularly in ports where congestion is a challenge. The second most meaningful measure is the total turnaround time in port as a function of cargo tonnage to be handled during the call, while the third measure will be total turnaround time in port as a function of a cargo sector, which in this case is containers. A measure of the duration of the vessel's stay in port is therefore regarded as an important overall indicator of the quality of service a port has to offer to its major users.

De Monie (1987) analyses the quality of how cargo is handled at a port, as a function of the total turnaround time. He articulates the fact that measuring port performance and efficiency based on the duration of a vessel stay in a port is not sufficient and would not actually demonstrate the efficiency and quality of port operations. The ship could be in port and be worked on immediately or be in port and not be worked on immediately. According to De Monie, to effectively measure the cargo-handling performance, the two groups of indicators required are output and productivity. The output results will provide information on work done on the tonnage of cargo over a period looking at berth throughput, ship output as well as gang (labour) output. Berth throughput measures the total tonnage of cargo handled at berth in a stated period and it is only an indicator of the facility activity, not of efficiency. Ship output is an indicator of how good cargo-handling operations are, and its measures include tons per ship working hour (SWH), tons per ship hour at berth and tons per ship hour in port. Gang output is the average tonnage of cargo handled by a gang in a certain interval, indicating the level of performance by the labour force. In a container sector, gang output is measured in containers handled per gross crane hour (GCH).

De Monie (1987) point outs that the indicators of cargo-handling productivity are different from those of cargo-handling outputs. Cargo-handling productivity indicators present the relationship between the output achieved and the effort put in, expressed in monetary terms (cost effectiveness). A less costly handling operation is regarded as more cost-effective which will bring about a certain amount of production, though not necessarily good productivity. It is possible at berth to handle more cargo by employing more men per gang, more gangs per ship, using more equipment and storage space to produce more output; however, the increased effort does not guarantee higher productivity and the operation might no longer be cost effective. In a congested port, cost effectiveness does not take precedence due to the fact that more resources would need to be deployed in order to man vessels as quickly as possible – and that comes at a price of increased labour and other resources. A possible counteraction to be taken in this instance, as suggested by Bennathan and Walters (1979), is that of applying the concept of congestion pricing, mainly in developing countries. Port congestion results from an increase in demand to that gateway, therefore the solution to controlling the demand is to look at the port pricing structure and impose a fee in order to achieve priority access. In this way, traffic during congestion could be controlled or reduced.

There are many other categories of performance indicators to be considered when measuring port efficiency and productivity, as argued by Trujillo and Nombela (1999). These authors have reduced the indicators into three broad categories:

- **Physical indicators** measuring ships turnaround time, ship waiting time, berth occupancy rate and working time on berth;
- **Factor productivity indicators** measuring labour and capital requirement to load and unload goods;
- **Economic and financial indicators** referring to the operating surplus or total income and expenditure related to gross registered tons (GRT) of a vessel or TEUs in relation to sea access.

Further, Trujillo argues that the port system in its very nature is complex and dynamic, which requires multifaceted and integrated approaches for measuring, evaluating and analysing performance to ensure high levels of productivity. A uniform and integrated system for evaluating productivity of container terminals is therefore essential in order to create a port ecosystem that is service-orientated, largely free of bureaucracy and has excellent connectivity both physically and electronically between all stakeholders involved.

Tongzon (1995) recommends several other broader approaches to measuring port efficiency, depending on which aspects of the port operations are being evaluated. These include:

- **Throughput –** geographical locations, frequency of ship calls, port charges, economic activity and terminal efficiency;
- **Efficiency –** container mix, work and labour practices and delays, crane efficiencies in relation to vessel size, cargo exchange in relations to economies of scale, berth utilisation, land utilisation, container dwell time, storage utilisation and gate throughput.

Tongzon regards vessel turnaround time as a crucial factor to container terminals, since this is a key issue in terms of the port's competitiveness and there are several practical explanations for this:

1. Large vessels tend to call at several ports in a multiport itinerary (Baird, 2006). Consequently, retardation in one of the ports on the itinerary will cause a delay for the next ports.
2. Berth allocation possibilities for ports are limited. During peak periods accompanied by operations inefficiencies, this might cause vessels to wait for longer periods at anchorage as a result of slower turnaround times.

The explanations stated above are of course interrelated. On the one hand, waiting in one port will cause delayed arrival of vessels for the next port. On the other hand, the incurred delays could also cause additional waiting time in the next port, and stand a chance of compromising or missing the allocated berthing window. In short, from the viewpoint of the customers who want to have their containers delivered on time, it is important that the vessel turnaround and waiting time at ports is minimised in order not to incur unnecessary penalty costs including potential demurrage and crew costs (Tongzon & Heng, 2005). There is also a foreseeable power shift from a carrier-centric to a shipper-centric model in port economics, which will put emphasis on port efficiency as an imperative (Notteboom, 2004). It is in the best interest of the ports to reduce ship turnaround time and improve port productivity, to ensure that the economic advantages of large vessels are not cancelled out by long port stay.

Additional scholarly literature continues to consolidate comparable frameworks and performance indicators in order to generate consistent benchmarks for assessing efficiency and productivity at container port terminals. Robinson (1999) put together the following approaches in this regard:

- Port productivity can be measured focusing on the short-term and long-term approaches. The short-term measurement consists of four distinct areas including stevedoring processes, gate cycles, yard operations and intermodal cycles. The long-run category measures the throughput (terminal throughput density and berth throughput density) and container storage dwell time.

- There is also an option of utilising a combination of performance indicators to measure productivity. The combination can be factors such as port accessibility, berth productivity and gang productivity. Port accessibility refers to the geographic location of the port; berth productivity measures the rate at which cargo is handled at a particular size of berth, and gang productivity measures the rate at which labour maximises its performance through high crane productivity.

For holistic port productivity measurements, quayside operation cannot be the only indicator to demonstrate the level of a container terminal performance. The landside operations are equally important in ensuring a seamless process of clearing cargo, physically and administratively, and moving it on to the next mode of transport, into the hinterland. Seaport competitiveness is also determined by how well the seaport-hinterland transition is designed and managed in relation to port efficiency and shaping up sustainable supply chain solutions.

Notteboom et al. (2008) note that several indices are used to measure various factors contributing to port performance including physical infrastructure, management and services, governance, regulations, customs and the institutional framework. When considering the port efficiencies specifically in sub-Saharan Africa, performance has been suboptimal compared to similar ports in Asia. Notteboom, in his contribution to the African Development Bank's paper on "Port Development in Africa" (2010), narrowed down his analysis to two major and specific performance indicators of port efficiency, namely turnaround time and container dwell time. According to Notteboom, the primary measure of port performance is the average turnaround time expressed in hours per ship, and tonnage handled per ship per day in port. Turnaround time is calculated from the time the ship arrives in port to the time of its departure. In its basic form, ship turnaround time does not mean much because the length of stay is influenced by a number of factors including the volume and type of cargo to be handled as well as available facilities necessary to handle the cargo. Turnaround time can further be used as an indicator of all delays (idle time) in port, serving as a good indicator of whether a port is congested or not. In measuring turnaround times or tonnage handled per ship-hour, a port would normally split the total time in port into 'time at berth' and 'time off the berth', thus capturing the total number of delays as well as the reasons for the delays. The second efficiency indicator Notteboom refers to is dwell time of cargo in port. This is a performance indicator used by exporters and importers in assessing the performance levels of a port. Dwell time is measured in terms of the number of days a ton of cargo remains in port after discharge. A high dwell time generally gives an indication of an inefficient port operation.

Suboptimal operations in ports, leading to productivity and efficiency constraints, have significant implications for the entire supply chain as well as transport costs, making shorter dwell times a critical factor in enhancing a port's competitiveness. In Africa, dwell time is significantly high in most ports averaging 20 days (Raballand et al., 2012). South Africa and Kenya are the two most efficient ports with dwell times averaging four to seven days, making these countries destinations of choice for most shipping lines, (Raballand et al., 2012). Dwell time, unlike ship turnaround time in ports, indicates areas where significant improvements may be applied. It does not, however, provide a thorough breakdown of various procedures that need to be completed before cargo is shipped or delivered. Dwell time is therefore just one indicator that port management needs to target to make sure there is sufficient integration of port operation so that cargo stays for shorter periods of time in the terminal yard. Failure to address dwell time will lead to high congestion levels, adding to constraints of a terminal becoming competitive globally. Notteboom (2006) calculated that in East Asian ports, the time spent in port averages 20 per cent of the total transport time, whereas in Africa, the average time spent in port is approximately 80 per cent of total transport time. It is therefore concluded that the higher and longer the dwell times in ports are, the more congested a port tends to become.

With regard to the key performance indicators for measuring productivity insofar as trans-shipment traffic is concerned, volumes have been growing more than three times as fast as the port-to-port segment in the last decade, making trans-shipments the fastest growing component of the container port market (Notteboom et al., 2007). The productivity and efficiency of a hub/trans-shipment port is determined by the ship turnaround time, short transit times, high labour efficiency, high crane efficiency, number of berths available, yard clearance, reduced reshuffling of containers, adequate storage facilities, quality and effectiveness of the ports information system (Tan, 1998; Low and Johnston, 2003).

2.2 Port productivity optimization

There have been a number of theoretical studies aimed at optimising operations and resource allocation within a container terminal yard. The published Swiss Transport Research Conference report (2007) highlighted the importance of identifying holistic and clearly defined indicators that can be used to evaluate the productivity and efficiency of a container terminal and to use those KPIs to adopt a decision support system that will optimise objective functions based on such indicators. The report distinguished and summarised two main classes of KPIs, which the terminal authority and operator have the responsibility to optimise, as follows:

- **Service–orientated**: these KPIs will measure the service levels provided to clients and are usually expressed in turnaround time of both the shipping lines and outside trucks. This class of indicators will need to be developed in order to take into account the competitiveness of the terminal and includes berth service time and gate service time.
- **Productivity–orientated**: the KPIs measure the volume of container traffic managed by the port terminal, in other words, annual TEU volume throughput, crane utilisation, crane productivity, berth utilisation, land utilisation, storage productivity and gate throughput.

Survey peer-reviewed literature done by Vis and de Koster (2003) as well as the study by Chen, Hsu and Huang (2003), employ traditional operations research methods to attempt to optimise single, multiple or all sections of a container terminal operation in order to increase port efficiencies and advance operations planning to gain improvement in contemporary port performance. Six optimisation areas have been identified and differentiated and these include issues relating to:

1. **Quayside transport optimisation –** this is optimisation achieved through reducing transportation time and the harmonisation of the crane loading and unloading sequence of the quay with that of the transportation (Rashid and Tsang, 2013);
2. **Berth allocation –** refers to the minimising the total amount of ship to yard distance for all containers during loading and unloading process (Karafa et al., 2013);

3. **Crane allocation –** refers to the distributing cranes for the bays of a ship and the operating schedule at the bays (Liang et al., 2009);
4. **Storage space allocation –** the determination of which block and slot is to be selected for a container to be sorted in the yard, thus minimising repositioning of containers (Bazzazi et al., 2009);
5. **Empty container movement or repositioning** – this factor refers to minimisation of the inefficiencies in container operations through repositioning empty containers in order to make space available to meet cargo demand (Song and Carter, 2009);
6. **Integrated approach (simulation and analytical) –** improvement of container terminal performance using many components that are functionally interconnected. These can be classified into simulation approach (computer modelling) or analytical approach (mathematical modelling and optimisation algorithms).

Vessels on a liner service sail from one port to another through fixed routes in order to gain economies of scale and better ship utilisation. At each port, thousands of containers may be loaded, unloaded or repositioned. Such container movement plans reduce transportation cost per container but pose difficult operational problems known as container stowage problems (CSP). A stowage plan includes the placement of a container at a ship slot having a combination of stack number, bay number and a tier number. The main goals of a good stowage plan are to minimise the port stay times of a vessel, ensure vessel stability and obey stress operating limits of the vessel itself while maximising quay crane utilisation (Gharehgozli et al., 2014). When preparing a stowage plan, several constraints have to be taken into account including, but not limited to, the container size, weight, height, port of unloading, and container type (reefer, International Maritime Dangerous Goods). The complexity of developing high quality stowage plans will further increase when shipping lines deploy mega-ships with higher storage capacity such as the MAERSK’s 18,000 TEU Triple-E vessels and larger. Delgado et al. (2012) suggest that the one way to deal with the CSP complexities is to decompose the problem hierarchically into a multiport master planning phase and a slot-planning phase. The multiport master planning involves a process where the hatch-over stowage and crane utilisation measures are optimised by determining the number of 20 foot and 40 foot containers that need to be stowed in the location, whereas the slot planning refines the master plan by assigning the containers associated with each location to specific slots in the location.

Additional literature describes how the use of technology in boosting port productivity is regarded as best practice. Schmidmeir (2006) regards technology as an enabler of best practice and argues that the container terminal operating system places more emphasis on 'over-customisation' and 'under-integration'. He summarises best practice categories under container handling equipment dispatch, yard sacking, crane scheduling and storage planning as follows:

- Pooling and routing straddle carriers across multiple cranes which will lead to increased yard equipment utilisation instead of assigning each straddle carries to a single and specific crane;
- Automated yard stacking control necessary to increase yard capacity and to substantially reduce re-shuffling of containers compared to manual stack planning;
- Automated stowage planning necessary to improve efficiency over manual vessel planning;
- Optimising crane scheduling to improve crane and labour productivity and reduce vessel turnaround time over manual planning and communications.

Other additional productivity improvement techniques can be deployed in a container terminal. One technique that is not widely practised but is fairly effective is called the double cycling approach. Double cycling is a technique that can be used to improve the efficiency of quay cranes by eliminating some empty crane moves, allowing for containers to be loaded and unloaded simultaneously. The crane efficiency improvement can be used to reduce ship turnaround time and therefore improve port's throughput and address capacity challenges. The concept of double cycling does not appear in the academic literature; however it has been a recognised concept in the industry for at least 19 years (Goodchild, 2005). Goodchild and Daganzo (2006; 2007) have considered the double cycle operations and suggest a scheduling method only for stacks under a single hatch cover for the first time, showing that the

Johnson's rule[3] can be applied when sequencing the discharging and loading tasks for stacks. The authors provide a method to evaluate the effect of the dual cycle operations on the reduction in the number of cycles during the ship operations, and they analyse the impact of the dual cycle operations on the landside operations. Although double cycling will not necessarily eliminate port congestion, it can be implemented quickly in conjunction with other measures and ease congestion before more long-term infrastructure projects come on line.

In this chapter, literature on various methods used and performance indicators in measuring the efficiency at container ports terminals has been reviewed. The literature highlights the fact that container port terminals are recognised as complex organisations. The most important objective for a container port terminal is to strive towards increasing its throughput and reducing the amount of time a vessel spends in a port terminal as well as efficient landside operations. Achieving this objective will depend on the effectiveness of allocating and scheduling key resources including, but not limited to, quay cranes, yard cranes, berths, gate management, trucks, information technology and labour. This effectiveness will be realised through efficient organisation and management capabilities as well as careful planning in order to oversee the entire port's operations and ensure that congestion costs are avoided. In narrowing the port performance measures, sets of generally accepted key performance indicators are available from both the financial and operational points of view. The same performance measures apply to trans-shipment hubs, which constitute the fastest growing component of the container port market.

Finally, from the literature review, it is evident that challenges lie in the fact that there are no standard methods that are accepted as applicable to every port for the measurement of its performance (Cullinane, 2002). Robinson (1999) concludes, however, that port efficiency measurement will always have a natural tendency to be terminal-specific. As articulated by De Monie (1987), the measurement of port productivity has been greatly impeded by the following limitations:

- The sheer number of parameters involved;

[3] In operation research, Johnson's rule is a method of scheduling jobs in two work centers in order to find an optimal sequence of jobs to reduce to the total amount of time it takes to complete all jobs. It also helps to reduce idle time between the two work centers. (Wikipedia)

- The lack of up-to-date, factual and reliable data, collected in an accepted manner and available for dissemination;
- The absence of generally agreed and acceptable definitions;
- The profound influence of local factors on the data obtained;
- The divergent interpretation given by various interests in identical results.

South Africa is deemed to be a strategic transport corridor and has a gateway status for the southern African region, Far East, Europe, South and North American trade routes. It is a strategic node contributing to the economic development of the country. South African port terminals continue to play a substantial role in regional containerised transit and the growing import and export market, which in turn must maximise the infrastructure available in order to reach competitive levels of productivity and efficiency. South Africa is in line with the generally adopted key performance indicators according to the literature presented, and the question is whether the level of productivity is as high as it should. The principal goal of this research dissertation will therefore be to investigate this question more fully.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

Port productivity in the South African container sector is characterised by suboptimal and inconsistent performance. Reliability, in terms of the resources used to create efficiency, has been poor. This research aims to test a hypothesis that, with the current port infrastructure and resources, improved levels of productivity, reliability, efficiency and increased throughput can be achieved. The resources mentioned refer to the marine, quayside and landside infrastructure as well to labour and technology. The methodology will seek to test some of the views presented in the literature on port performance measurement and optimisation. This chapter has four aims: (1) to describe the research methodology, (2) to explain the rationale behind the sample selection and the criteria used, (3) to describe the instruments and methods used to collect data, and (4) to elaborate on the analysis design of the collected data.

The research methodology will be based on both quantitative and qualitative analysis in order to capture sufficient data to assist in analysing the trends. The quantitative method will be based on the determination of the baseline capacity data of the current infrastructure and resources at the container port terminals, in line with the identified variables in accordance with the key performance indicators for measuring productivity. For the sake of this dissertation, these will include total port turnaround time (TPTA), berth occupancy, cargo handled per ship working hour (SWH), cargo handled per gross crane working hour (GCH), dwell time and truck turnaround time. The SWH and the GCH data will also demonstrate the performance of the landside transport (RTGs, straddle carries, hauler) and labour, since that they form part of the input required to achieve higher SWH and CGH. The qualitative method will entail collecting and analysing the actual efficiency and performance data from the sample selected and then match matching this against the baseline data in order to make a comprehensive review. The gaps will be identified and discussed and a benchmarking study will be done on four similar ports outside South Africa. The analysis will also briefly examine the impact of productivity on container volume throughput from the years 2012, 2013 and 2014 respectively.

The port performance will be analysed based on a selected sample consisting of two categories, namely container berths at respective terminals as well as two types of vessel sizes calling at those terminals. This will include the Durban Container Terminal (DCT) Pier 2 i.e. the North, South and the East quays, Ngqura Container Terminal (NCT) and the Cape Town Container Terminal (CTCT) together with the following vessel types, calling at the respective ports:

- A gearless vessel with an approximate call size of 4000 units;
- A vessel with approximate call size of 2 000 units.

The productivity baseline data of the selected berths in terms of SWH, GCH, dwell time and truck turnaround time, will be presented and analysed according to the berth's characteristics and potential performance capacity. For the GCH specifically, the technical data of the crane characteristics will be drawn from the original manufacturer product description of the typical parameters and profiles of the crane. Thereafter, the observed actual performance data of the berths and its variables will be presented and analysed against the baseline in order to determine the performance gaps. In determining the consistencies of the total port turnaround time and performance patterns, a comprehensive analysis will be done based on 40 traffic observations on both of the abovementioned call size vessel categories over a period of six months at the selected container terminals.

Since the port turnaround times vary daily, in order to measure and quantify the variations, the standard deviation statistical method will be used to analyse the 40 observations. The standard deviation is a widely used method seeking to determine the dispersion of a set of data from its mean. The more spread apart the data is, the higher will the deviation be, which in this regard will indicate the level of consistencies or inconsistencies in port turnaround times experienced at the container terminals under consideration. A comprehensive analysis of the actual turnaround time patterns will be discussed, assessing factors contributing to performance and potential deviations. The benchmarking sample will include the port of Santos (South America), Colombo (Sri Lanka) and Melbourne (Australia). The criteria considered in choosing the profiles of the selected comparators were based on the similarities to the South African container port sector. Their jurisdictions have similar characteristics of a landlord nature and they service similar trades and container throughput. In addition, the criteria used for selecting the sample to determine the baseline and the actual data was based on:

- Size of the call of the container vessel;
- Type of the container vessel;
- Number of gantries deployed;
- Supporting equipment (straddle carriers, RTGs and haulers) behind each gantry.

In this way, a comprehensive analysis and multiple perspectives can be drawn out on most factors affecting efficiency and productivity, given the infrastructure and the resource capacity.

The primary instruments used in collecting quantitative data will include the physical observation of the terminal operation in order to simulate and arrive at a conclusion of what the optimal performance should be. The secondary instruments used to collect qualitative data will be based on the actual performance reports drawn from Vessel Performance Reports and Container Movement Reports for a period of six months. Additional data will be drawn from the berth plans received from the port with details on volumes, berth duration and crane allocations. Because most shipping lines sign performance contract agreements with the terminal operator, confidentiality of key information is critical, and this limits access to information on the actual performance of the ports.

The data for performing the benchmarking study will be drawn from publicly available sources on the identified ports. Most of the benchmark ports have published annual reports on their official websites, containing specific and relevant information sufficient to permit a meaningful analysis for the purpose of the benchmark study. Some of the benchmark ports selected did have most indicators published, namely Tecon Santos and Port of Melbourne, while the others had only limited data publicly available. These factors brought about some limitations in drawing out specific indicators for benchmark reasons. For the purpose of this exercise, the available indictors will be used as a mere guide since that container terminals are generally less diverse and have sufficiently common themes to enable the use of benchmarking performance against other ports of similar capacity and industry standards.

The data collected will be analysed and presented in a form of graphs and tables, and then discussed fully in Chapter 5. The research methodology will cover the necessary content that will be sufficient to address the research question and draw a meaningful conclusion on productivity capabilities in the South African container sector.

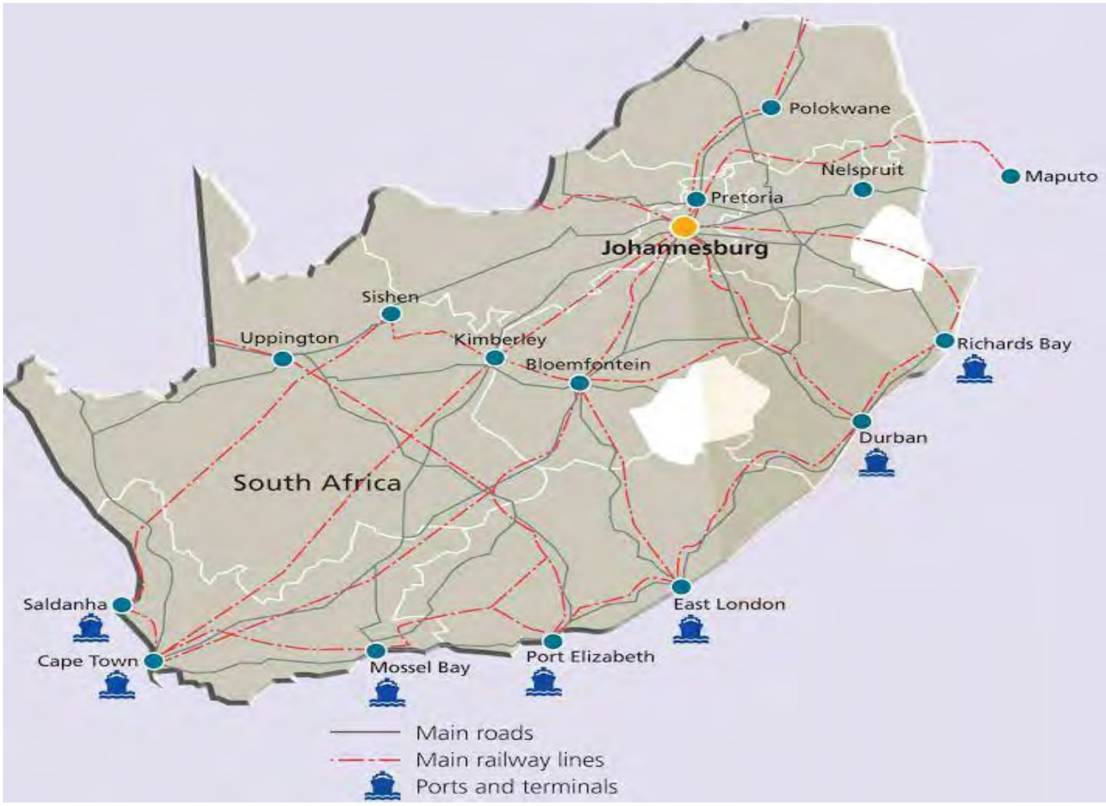
CHAPTER 4

OVERVIEW OF THE SOUTH AFRICAN PORTS

4.1 The South African port system

South African ports play a conduit role for trade between South Africa and all of its trading partners in the Southern African region and serve as a hub for traffic to and from the rest of the world. With more than 90 per cent of the world's trade volumes being seaborne, approximately 98 per cent of South Africa's exports are conveyed by sea through the eight commercial ports of the country (SAMSA, 2013) as indicated in Figure 4.1, namely Durban, Richards Bay, Cape Town, Saldanha Bay, Mossel Bay, Port Elizabeth, Ngqura and East London.

Figure 4.1: The South African commercial port system and the rail and road network



Source: SAMSA, 2013

South African ports are of a complementary nature in that they have a singular model of port ownership (landlord) and each port provides different services on specific types of cargoes regionally. Table 4.1 shows that the ports of Durban, Cape Town, Port Elizabeth and East London are predominantly multipurpose ports, handling containers, dry and wet bulk as well as break bulk and automotive cargo. The ports of Saldanha Bay, Richards Bay and Mossel Bay handle specialised bulk cargo, with Mossel Bay serving predominantly the fishing trade and also supplying service to the offshore oil and gas industry. The port of Ngqura is mainly developed to handle trans-shipment cargo. Table 4.1 indicates that the ports of Saldanha Bay and Richards Bay are both designed to accommodate the largest bulk carriers in the world, carrying a draft of 21.5m and 17.5m respectively. The complementary port system presents an advantage of scale, avoids duplication and provides a logical distribution of port facilities to meet the national logistic needs. All ports together, with their hinterlands, are connected by an integrated rail system comprising high volume port-rail corridors and over-border interconnections and high volume feeders, as presented in Figure 4.1 above.

Table 4.1: Principal South African ports: infrastructure and traffic base, 2014

PORT	TERMINALS	BERTHS	SECTOR	DRAFT
Richards Bay	6	22	Bulk, Break Bulk	17.5m
Durban	19	59	Containers, cars, Break Bulk, Liquid Bulk	12.8m
Port Elizabeth	5	12	Cars, Containers, Break Bulk	12.2m
Port of Ngqura	5	4	Containers	16.5m
East London	4	12	Cars, Break Bulk	10.4m
Mossel Bay	2	8	Liquid Bulk, Fishing	6.5m
Cape Town	7	45	Containers, Break Bulk	15.5m
Saldanha	3	7	Bulk, Break Bulk	21.5m

Source: TNPA Port Development Plan, 2014

In 2014 the total container traffic passing through South African ports reached 4.64 million TEUs, dry bulk volumes reached 159 million tons, liquid bulk volumes reached 39 million kilo litres, break bulk volumes reached 15 million tons and automotive volumes reached 692 000 units (TNPA, 2014). Table 4.2 shows that South Africa experienced a modest increase in port traffic from 2013 to 2014, mainly on the container, automotive and the dry bulk sectors with a slight decline of volumes on the break bulk cargo. This is as a result of the shift from moving most commodities as break bulk to containers, allowing for better and efficient handling of cargo.

Table 4.2: Total volumes handled at South African in 2013/14, according to cargo sector

	2013	2014
Dry/wet bulk (metric ton)	**197 676 050**	**198 597 927**
Break bulk (metric ton)	**16 235 735**	**14 561 111**
Container (TEUs)	**4 403 358**	**4 641 205**
Automotive (Units	**667 266**	**692 287**

Source: TNPA, 2014

There has been a decline in the number of vessels arriving on South African shores since 2003, decreasing from 14 300 per annum to approximately 12 122 in 2014 (TNPA, 2013/14). Since the economic downturn, shipping lines have sought to stay competitive by running and deploying fewer larger and more fuel-efficient vessels instead of many smaller-sized vessels in pursuit of economies of scale and greater efficiency. Another major aspect relating to the tonnage capacity shift was an observed trend of continued influx of ultra-large container vessels deployed in the higher-density northern hemisphere trades. This influx led to a large number of vessels being cascaded onto other trade lanes, mainly in developing economies that historically have been served by smaller vessels. The South African ports are now faced with container vessel callers up to 13 000 TEUs on a regular basis, with Latin American trade experiencing a large increase in similar tonnage (Container Shipping & Trading, 2014).

The South African port infrastructure is fully owned by Transnet National Ports Authority (TNPA) with certain key port operations, notably container handling and the automotive trades, being driven by Transnet Port Terminals (TPT) which – like the TNPA – is wholly owned by the South African Government. Table 4.3 highlights the public and private sector market share for major service categories. TNPA is primarily an asset manager, providing a limited range of port services including marine services (pilotage and towage) while TPT handles cargo operations at the ports. The private sector dominates the cargo-handling landscape in respect of lower-valued dry bulk and liquid bulk cargoes at 63 per cent of the total volume with TPT handling the majority of the container sector amounting to 97 per cent of the total container volume (Trade and Industrial Strategies Report, 2014).

Table 4.3: Public and private sector market share for major service categories

Services	TNPA	Port operations	
		TPT	Private
Marine services	100%		
Bulk cargo handling		37%	63%
Break bulk cargo handling		78%	22%
Car (on wheels) handling		100%	
Container handling		97%	3%

Source: TIPS, 2014

4.2 The container sector

There are four major container terminals in South Africa, all designed in the form of a multiple gateway system, consisting of the port of Durban (main port), Cape Town, Port Elizabeth and Ngqura. The South African container terminals have a total capacity of 7.4 million TEUs; with the total container volume handled reaching approximately 4.64 million TEUs in 2014, representing an increase by 5.4 per cent from 4.4 million TEUs in 2013. Out of the total volume throughput, the port of Durban has handled 65 per cent of the total volume, with Cape Town handling 19 per cent and Port Elizabeth/ Ngqura handling a combined 14 per cent of the total volumes (Transnet: Integrated Report, 2014).

4.2.1 Key performance indicators at South African container terminals

TNPA, as the landlord of the South African ports, has the responsibility of performing port operation oversight to ensure that the terminals remain internationally competitive. This is achieved by evaluating critical operational performance standards to improve marine and terminal performance according to targets, benchmarks and customer expectations. TNPA and TPT are guided by sets of standard productivity KPIs summarised as follows:

Table 4.4: National Ports Authority: KPIs for all container terminals in South Africa

	Anchorage waiting time/hr	Ship turnaround time/hr	Berth occupancy (%)	Berth utilisation (%)
Port of Durban	46	57	70 – 80	70 – 80
Port of Cape Town	34	30	60 – 70	50 – 60
Port Elizabeth	30	26	55 – 65	55 – 65
Port of Ngqura	50	45	75 – 85	75 – 85

Source: Transnet Sustainable Report, 2014

Table 4.4 shows that TNPA has set operational targets for maritime operations and places its focus on only four performance indicators, these being anchorage waiting time, vessel turnaround time, berth occupancy and berth utilisation rates. These indicators are intended to measure a port's key value drivers, including reducing excessive port time, gaining maximum throughput and harnessing the overall port user experience for the container sector. Anchorage waiting time is a consequence of slow quay and yard operations and contributes towards the total port turnaround time for vessels that cannot berth on arrival. Longer waiting times at anchor are associated with general port congestion, and also contribute to that congestion, as do quayside and landside challenges. The landlord has kept the baseline target for anchorage waiting time at 50 hours for NCT, 46 hours for DCT, 34 hours for CTCT, 30 for PE, amounting to just over two days of waiting for a berth. The baseline seems to be premised primarily on the nature of service each port provides as well as the size of vessel calls, as seen with NCT and DCT.

The vessel turnaround time, in this regard, refers to the period between the time a vessel enters the breakwater, berths, loads and discharges – until its departure out of the breakwater – and different targets are set per individual container terminals in South Africa. Vessel turnaround time is a critical indicator for the quality of the quayside operational efficiencies and requires to be kept at a minimum in order for the landlord to allow for increased traffic. Similar to anchorage waiting time, for the Port of Durban, the set target for vessel turnaround time is 57 hours allowing for a maximum stay of at least two and a half days at berth. The Port of Durban has the highest turnaround time target compared to the other three ports; this happens as a result of Durban being the main port servicing larger call sizes. The Port of Ngqura has the second biggest vessel turnaround target compared to Cape Town and Port Elizabeth as a result of its trans-shipment nature and call sizes. The Port of Cape Town and Port Elizabeth have the lowest vessel turnaround time averages owing to the size of trades they service, which are predominantly smaller volume calls. The Port of Cape Town, in particular, has its baseline target set at 30 hours since that it is a gateway for very time-sensitive cargo such as citrus and other fruits, requiring shorter transit times.

The berth occupancy rate is an important indicator for the landlord as it represents the percentage of the total available time that berths are occupied by ships. This indicator is useful for obtaining the port's activity because it is in the best interest of the landlord to ensure that berths are neither under-occupied nor over-occupied. A very high berth occupancy rate would indicate that berths are always occupied and that ships cannot always berth on arrival. Slow-performing berths owing to operational challenges might also cause ships to stay longer at berth, thus keeping them occupied for extended periods or lying idle. On the contrary, a port with a much lower occupancy rate indicates a level of under–utilisation of infrastructure. Therefore a port needs to have its berth occupancy rate balanced out to a point where berths are fairly occupied and efficiently utilised so that ships can berth almost at arrival all the time. TNPA's berth occupancy targets averages between 55 and 85 per cent across the ports. Anything lower than 55 per cent or more that 85 per cent will compromise the performance of the port's activity, either through congestion or under-utilisation of port capacity.

Another important indicator of port efficiency is the degree of utilisation of a berth and this is measured by the berth utilisation rate. This is the percentage of the actual working time at berth in relation to the time that the berth is occupied. Since the berth occupancy and berth utilisation go hand in hand, their targets are almost similar at all four container terminals, as indicated in Table 4.5 below.

Table 4.5: KPIs for TPT and set targets for container terminals in South Africa

PORT	GCH	SWH	DWELL TIME
Durban Container Terminal (DCT Pier 1)	28	53	Import – 3 days
Durban Container Terminal (DCT Pier 2)	30	68	Export – 5 days
			Trans-shipments – 10 days
Cape Town Container terminal	32	55	Import – 3 days
			Export – 5 days
			Trans-shipments – 15 days
Port Elizabeth Container Terminal	27	45	Truck turnaround time – 35 minutes
Ngqura Container Terminal	32	55	Train turnaround time – 10 hours

Source: OECD International Transport Forum: The Competitiveness of Ports in Emerging Economies, 2013

With respect to the terminal operator's key performance indicators, Table 4.5 outlines the set targets on variables used to measure productivity and performance at the four container terminals. The terminal operator's objective, on the one hand, is to ensure higher utilisation of the quayside facilities in order to achieve higher throughputs leading to higher revenues. On the other hand, the ocean carrier envisages vessels spending shorter times in port. To achieve the stated objectives, the considered variables by the operator in the South African context include SWH, GCH, dwell time as well as the truck turnaround time. SWH, as indicated in the literature review, refers to the rate at which the terminal quayside infrastructure is able to load and offload container ships in an hour and it is a key consideration by customers of the operator in measuring overall port performance. Considering the given infrastructure capacity and the size of the quay with its superstructure, the SWH target for Durban (Pier 1), Durban (Pier 2), Cape Town, Port Elizabeth and Ngqura is set to be at 53, 68, 55, 45, 55 moves per hour respectively. DCT Pier 2 has the highest SWH target baseline because of the bigger number of deployed gantry cranes at the berths, necessary to reduce the number of times a ship has to be worked. For Durban Pier 2, specifically, the newly acquired ZPMC tandem and quart lifts ship-to-shore cranes are aimed at improving the SWH from the current baseline of 68 containers to a further 85 moves an hour, at full utilisation.

GCH is a key measure of the terminal's efficiency and indicates how well and optimally the terminal superstructure equipment is used during loading, discharging and repositioning of containers at in an allocated period of time. The operator's objective is to have a maximum number of container moves, uninterrupted, during a set hour in order to reduce vessel time at berth while gaining maximum throughput at the same time. According to Table 4.5, the GCH set targets for the ports of Cape Town and Ngqura are the highest at 32 moves per hour due to the ports being are equipped with newer cranes, requiring lesser attention on unplanned interruptions. Durban is, however, operated on a mix of older and new gantry cranes set to deliver an average GCH of 30 at Pier 1, and 28 moves at Pier 2, with PE having a GCH baseline of 27 moves per hour. The new cranes deployed are forecasted to deliver a GCH of 33 moves an hour in future (Transnet Corporate Brochure, 2014).

The third variable considered as a performance indicator by the terminal operator is the dwell time, which refers to the amount of time containers remain in the terminal's in-transit storage while awaiting to be loaded or collected by clearance transportation. In the entire supply chain, cargo owners have a responsibility of to ensure that they cooperate with terminal operators in order to improve the yard capacity efficiency. Weak management of yard capacity can result in unnecessary bottlenecks within a terminal and it is in the interest of the operator to put systems in place to manage and control yard fluidity as well as reduce the dwell time. Export, import and trans-shipments cargoes all have a potential of contributing towards a high dwell time, and all for different reasons. For export cargo, longer dwell time can result from a number of reasons factors including the non-loading of big consignment sizes, over-booked vessels and short-shipments of cargo due to incorrect stowage planning. For import cargo, the biggest contributor to longer dwell times is the customs blockages, cheap storage at terminal and customers not checking arrival notices in time. For trans-shipment cargo, dwell time is influenced by failure to meet vessels' connection between the pre-carrier and the nominated on-carrier. The average dwell time set for all container flows, by the terminal operator, is about three days, which is the most efficient in sub-Saharan Africa[4], where most terminals have twice as much dwell time. Export cargo dwell time is set for five days whereas import cargo is allowed a free dwell time of three days. Trans-shipments, on the other hand, are allowed a free dwell time of up to 10 days, which will allow for longer waiting periods to meet connections.

The truck turnaround time refers to the average time it takes a truck to enter the gate, get served and exit. The average truck turnaround time target is set at a maximum of 35 minutes from the time the truck passes through the terminal gate until it exits the port. This indicator is necessary for optimising yard operations and for allowing the truck's operation to be within its predetermined times in order to reduce any potential congestion in the terminal yard.

4.2.2 Overview of each container port terminal in South Africa

4.2.2.1 Durban Container Terminal (DCT)

DCT is one of the busiest container facilities in South Africa and the fourth largest container terminal in the southern hemisphere (Wikipedia). DCT serves as a pivotal hub for the southern African region, serving trade links to the Far East, Middle East, Australasia, South America, North America and Europe. The terminal also serves as a trans-shipment hub for East Africa and Indian Ocean Islands and it is well connected by road and rail networks. The terminal consists of a 2 128 metres quayside divided into 10 berths, 13 000 ground slots and 1 000 reefer points (TNPA Port Profile, 2014). DCT has a combined capacity of 3.6 million TEUs per annum and operates as two terminals, Pier 1 and Pier 2. DCT currently handles 65 per cent of South African

[4] World Bank: Why Does Cargo Spend Weeks in Sub-Saharan African Ports, Raballand et al., 2012

container volumes, which amounted to 2.66 million TEUs handled in 2014. Pier 1 container terminal consists of three berths, with an alongside water depth of 12.5 metres, and it is equipped with a total of six super-post panamax gantry cranes backed by a fleet of Rubber Tyred Gantries cranes in the stacking area. Rail and road access is also seamless out of Pier 1. The terminal has a nominal capacity of 700 000 TEUs per annum. Pier 2 container terminal consists of seven berths, with an alongside water depth of 12.8 metres (planned to be increased to 16 metres), with a fleet of over 100 modern straddle carriers, 19 shore side gantry cranes in service as well the new three of a total of seven tandem lift ship-to-shore cranes with a capability of loading or offloading 85 containers in an hour.

4.2.2.2 Cape Town Container Terminal (CTCT)

CTCT is the second largest container facility in South Africa consisting of a quay length of 1 137 metres, total ground slots of 5 250 and 3 751 reefer points. The terminal has a total of seven berths, a water depth alongside of 15.5 metres, employs eight ship-to-shore gantry cranes, 10 straddle carriers, 28 RTGs and has a capacity to handle a total of 900 000 TEUs. CTCT serves mainly the fruit export market and has been also providing trans-shipment services from the West African and South American regions.

4.2.2.3 Port Elizabeth Container Terminal

The Port Elizabeth container terminal serves the immediate hinterland of the Eastern Cape including all automotive manufacturing and assembly companies as well as agricultural products targeted for exports. The terminal consists of three berths totalling 635 metres, with 11 metres of water alongside, and is equipped with five shore side gantry cranes backed by 4 800 ground slots and 212 reefer points. The terminal has direct road and rail access and handled a total of 389 638 TEUs in 2014 (TNPA Port Profile, 2014).

4.2.2.4 Ngqura Container Terminal (NCT)

NCT is a premium trans-shipment hub capable of handling very large container ships (VLCS) and has a total capacity of handling 1.2 million containers per annum (Port Regulator, 2014/15). The terminal consists of four berths totalling 1.3km, a water depth alongside of 16.5m and is equipped with 10 mega-max ship-to-shore side gantry cranes, 40 RTGs and two straddle carriers backed by 60 hectares of stacking space and 1 680 reefer points. The terminal has direct road and rail access and has handled a total of 800 000 TEUs to date (TNPA, 2013).

Among the key strategic objectives of the ports authority and the terminal operator, growth in volumes and market share as well as increased efficiency and port productivity are regarded as priorities. The concern is to optimise the use of assets in order to achieve the targeted return on investments, optimise customer service levels and minimise vessel turnaround time. In achieving these objectives, the port terminal operator has in place a service level agreement known as the Container Terminal Operations Contract (CTOC) with key customers, including container shipping lines on their specific trades, which outlines the expected performance levels – known as norms – linked to the volumes to be handled. These norms bind the parties to the contract to deliver specific targets based on the KPIs on the part of the terminal operator, and specific deliverables and responsibilities on the part of the shipping line. It is important to mention that the CTOC is seen as critical to the success of the port performance and it is enforced by offering incentives to customers if they fully comply with the agreement and carry out port activities during the issued window period and clear cargo timeously from the port within agreed limits. Non-compliance with the CTOC agreement will result in the shipping line losing its window and will then be forced to queue on a first-come-first-served basis, causing delays and a ripple effect on the sailing schedules in other ports.

It is evident from these profiles of container terminals in South Africa that each terminal is different and the performance and productivity levels vary as a result of the different internal and external characteristics including layout, infrastructure, geology, cargo types and labour. Performance targets are set in line with the available infrastructure and the nature of trades and the different size of traffic passing through terminals. In testing the set targets against the current port productivity levels, this research dissertation will analyse the average real time performance and productivity at all three container terminals and identify the performance gaps and related limitations in line with the presented baseline targets discussed in this chapter.

CHAPTER 5

RESULTS: PRESENTATION AND DISCUSSION

In this chapter, the main findings and results are presented together with an analysis and discussion thereof. The results presentation is in line with the dissertation research hypothesis, which aims to illustrate the productivity gaps at each container terminal, given the current capacity and its potential performance relative to the actual performance profile. A detailed account of the sample and its respective characteristics is outlined. The baseline data calculations are presented as well as the operator's baseline targets, indicating the potential performance parameters. For the first part of the sample, the results aim to show what the GCHs and the SWHs should approximately be in as far as the current infrastructure capacity is concerned. The real time productivity data drawn from recorded performance reports of major shipping lines is presented, matched against the baseline, and a gap analysis is discussed. The dwell time and truck turnaround time are also discussed in this chapter.

The second part of the sample aims to illustrate the efficiency trends in relation to the total port turnaround time, looking mainly at the overall terminal and landlord's infrastructure performance. A standard deviation statistical method is used, which is a measure of how spread out numbers are from an average, and it is based on a series of 40 observations of two types of vessel call sizes over a period of 12 months, as mentioned in Chapter 3. The standard deviation method was considered an appropriate tool to illustrate the consistencies or inconsistencies of the time the vessels take in the ports, considering the infrastructure available both on the marine and quay sides. It considers the average time spent in the port as well the deviations away from the average, which will assist in giving a perspective on variances in port turnaround times at the container terminals reviewed in this research. Finally, benchmark port profiles will be presented in relation to the performance and productivity best practice at relevant international container terminals.

5.1 Sample characteristics and performance capabilities

5.1.1 Container terminal berth profiles

Table 5.1: Characteristics of the DCT (Pier 2), CTCT and NCT

Terminal	Berth	Berth Length	Cranes	Gangs
DCT Pier 2	North Quay	900m	7	6
	South Quay	504m	4	3
	East Quay	660m	6	3
CTCT	601 – 604	1180m	8	7
NCT	D100-104	1188m	10	8

Source: Transnet Ports Terminal Corporate Report, 2014/15

Table 5.1 outlines the characteristics of the berths at each of the container terminals. DCT Pier 2 has a distinct berth configuration (see EXHIBIT 1), which consists of three differently configured berths (north, south and east quays) each having a different quay length size and different number of cranes deployed. Table 5.1 shows that the north, south and east quays have berth lengths of 900 metres, 504 metres and 666 metres respectively, with a common water depth alongside of 12.8 metres. Table 5.1 further indicates that the crane deployment at DCT is proportional to the size of the quay length in that the north quay is equipped with more quay cranes than the south and the east quays. In terms of the number of vessels each berth can accommodate, the north quay is divided into three berths, each having a capacity to accommodate vessels with a length of approximately 300 metres. However, the berth normally handles a total of two vessels at any given time, with cranes spread according to the call size. The south quay can accommodate a vessel with a length of 350 metres and the east quay can accommodate two vessels with a length of 300 metres each alongside (Transnet Port Terminal, Sustainability Report, 2014). The north and the south quays are referred to as prime berths owing to the deployment of fairly new types of cranes (tandem lifts, super-post-panamax and post-panamax ship-to-shore) servicing ships of greater commercial value, with TEU carrying capacity of 4 500 to 12 000 containers. The east quay is regarded as a non-prime berth in that it uses older generation quay cranes (post-panamax ship-to-shore, twin lifts) generally servicing somewhat smaller deepsea and feeder vessels with TEU carrying capacity of 2 000 to 3 000 containers.

As a result of different terminal berth configuration, CTCT and NCT have their berths designed in one straight line, each having a berth length of 1 180 metres and 1 188 metres, respectively. The CTCT has three active berths, which can accommodate three vessels of 350 metres each and is equipped with eight super-post-panamax ship-to-shore twin lift gantry cranes. The NCT is divided into four berths with only three berths in service, each accommodating vessels up to 350 metres in length. The berths are serviced by a total of ten mega-max, ship-to-shore, twin-lift gantry cranes and spread across the berths according to the size of the call.

In addition, Table 5.1 shows the workforce planning and distribution at quayside operations at each container terminal. Each gantry crane is handled by a group of labourers referred to as gangs. In South Africa's case, for every crane, a group of six labourers are placed to work on a crane. These include crane drivers as well as stevedores for lashing the container. However, each vessel is served by a total of three gangs at a time as stipulated in the operator's Standard Operating Procedure manual.[5] The ground transporters also form part of the gang as straddle and truck drivers, bringing the total number of gang members to approximately 12 at a time.

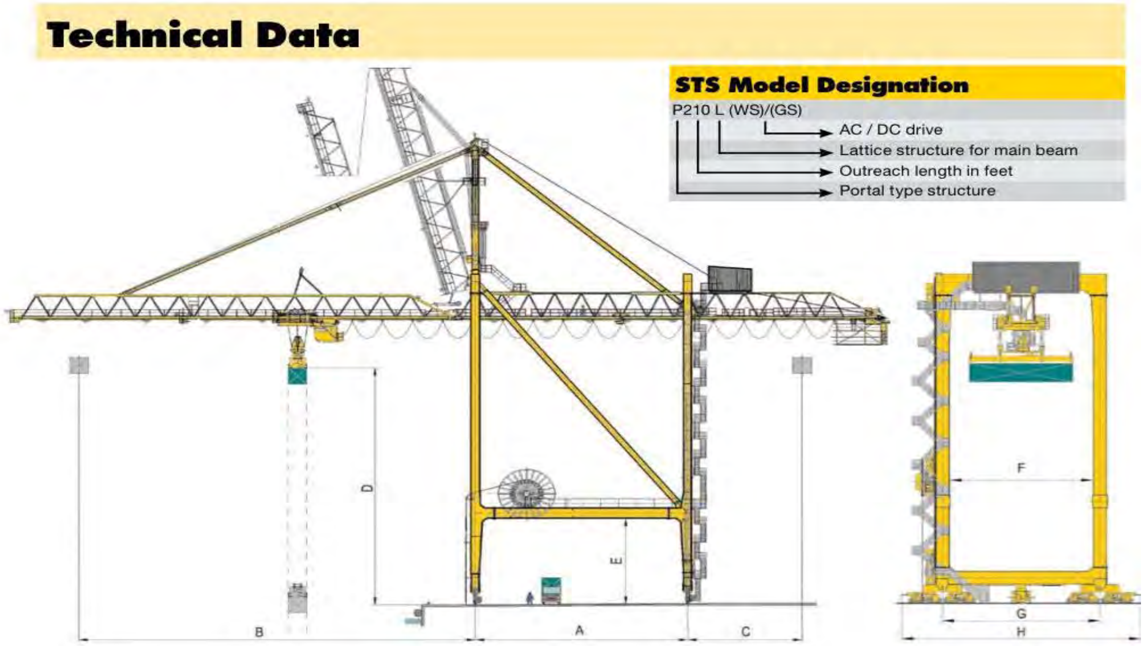
5.1.2 Baseline data and performance capabilities

In order to illustrate the performance and productivity gaps at each container terminal, performance baseline data was determined so as to indicate the productivity potential of the sample berths. The first baseline data determination was on the GCH, and the data was based on the types of cranes deployed in the respective berths. The north and south quays at DCT Pier 2 (prime berths) as well as the NCT and CTCT are equipped with super-post-panamax as well as post-panamax cranes, which are capable of taking two minutes to load or unload a container. The two minutes is informed by the total time it takes to hoist (lift) a container, carry it through the trolley, dropping it into the vessel hold and the reverse movement back to picking up another container, as

[5] Transnet Ports Terminals - Standard Operating Practice (2013), which is a document that is used for promoting common understanding between the operator and the shipping line on berthing and operating cargo vessels.

indicated in Figure 5.1 below. According to the technical data of the cranes (Liebherr technical specification report, 2015), an average speed of 120 metres per minute is achievable for a super-post-panamax crane to hoist and/or lower a container. When considering the characteristics of the crane, the lift height averages 30 metres and the drop height averages 40 metres, bringing the total time it takes to hoist and drop a container to approximately 35 seconds.

Figure 5.1: Liebherr technical data report (2014)[6]



Source: Liebherr Equipment Technical Description

The trolley distance of a super-post-panamax crane is 59 metres, comprising the back reach distance (three metres), the gantry span (25 metres), the distance between the gantry leg and the ship-side (seven metres) as well as the average beam[7] (48 metres) as indicated in Figure 5.1. The average trolley speed is 210 metres per minute, making the total time it takes to move the container across the trolley 17 seconds. It therefore take 1.7 minutes to pick up a container, drop it into the hold and return the crane into a position to pick the next box up. The remaining three to five seconds are made up of the time it takes to locate the container before clamping or unclamping it as well as

[6] A: Gantry Span, B: Vessel Outreach distance, C: back Reach, D: Hoist (Lift and drop height).

[7] Outreach distance is a maximum distance a trolley can travel to discharge a container. On a super-post-panamax crane, the maximum outreach is up to 19 containers across which is equivalent to a beam of 48 metres.

locating the cell guide in order to release the container into position. The two minutes it takes to load or unload a container amounts to a GCH of 30 moves an hour on a single lift basis, which should be the baseline performance given the characteristics of the crane used at the respective berths.

For the sake of this dissertation, it was important to analyse the set targets created by the operator, having considered the available infrastructure in relation to what the terminals can achieve in order to test the considered performance limitations. As currently is the case, the infrastructure is not giving the performance as expected; the reasons for this are discussed below.

Table 5.2 below presents and summarises the considered baseline GCH targets set by the terminal operator at the respective container terminals.

Table 5.2: Port terminal operator GCH baseline data

PORT	GCH
	Target
DCT - Pier 2 – Prime Berth	28
DCT Pier 2 – Non-Prime Berth	20
CTCT	32
Port of Ngqura	30

Source: Transnet Integrated Report, 2015

DCT Pier 2 is set to perform at a GCH of 28 moves per hour, which is slightly lower that what the cranes can produce, namely 30 moves per hour. The difference in the number of moves is an allowance given for maintenance schedules as well as the different distribution of working hours of cranes deployed. At DCT Pier 2, the non-prime berths have a GCH target of 20 moves per hour, as indicated in Table 5.2 and their lower target is a result of the cranes being more than 20 years old (Ports.co.za, 2013) and having lower hoisting, dropping and trolley speeds, resulting in one move taking up to three minutes to complete a load. CTCT and NCT are equipped with new cranes, which allow the terminal to achieve the GCH as expected, namely 30 and 32 moves an hour respectively.

The second baseline to be considered in the productivity and performance at the container terminals was the SWH. An analysis was done on the optimal ship-working hour the three terminals can achieve, given the available terminal equipment both on the quayside and the landside, with making some allowance for delays. SWH refers to the number of container units handled in an hour across the vessel, from the time the vessel commences cargo operations to the time the vessel completes cargo operations. Its measure considers all variables involved in the process of discharging and loading. These variables include the number gantry cranes deployed, the supporting equipment behind each gantry (the number of straddles, RTGs, haulers as applicable). Delays in the form of equipment breakdown (gantries, straddles, RTGs), as well as imbalances with regard to the number of moves allocated to each gantry (which will have an impact on the completion times of each gantry) are factored in when calculating the optimal SWH.

As stated above, the prime berths should have a GCH of 30 moves per hour and with three cranes deployed to a vessel with a length of 350 metres, an SWH of 90 moves per hour should be achieved for the prime berths and 60 moves per hour for the non-prime berths. However, in every loading and unloading of containers, delays are inevitable, thereby lowering the actual hours the ship is worked on thus adjusting the ship working hour rate to achieve a somewhat lower realistic number of moves. The operator has set an SWH baseline target of 62, 43, 52 and 51 moves an hour for DCT Pier 2, CTCT and NCT respectively, as indicated in Table 5.3.

Table 5.3: Port terminal operator SWH baseline data

PORT	SWH
	Target
DCT - Pier 2 – Prime Berth	62
DCT Pier 2 – Non-Prime Berth	43
CTCT	52
NCT	51

Source: Transnet Integrated Report, 2015

The operator reduced the SWH targets after consideration of certain factors, including the most important delays such as:

1. Equipment breakdown;
2. Weather interruptions;
3. Agents/carriers delays – hatch cover removal, re-stows;
4. Administrative delays including shift changes and worksheets exchanges;
5. Delays resulting from improper housekeeping, such as when a stack is not well arranged and does not reflect the correct stow plan on board the vessel, and this disrupts the smooth flow of units into the vessel, requiring unnecessary shuffles that could be avoided with proper planning. Prior to loading the units on board the vessel, the units in the stack need to be arranged in order to facilitate uninterrupted flow, without having to reshuffle the units in the stack itself.

It was also noted that DCT has a higher SWH target than CTCT and NCT owing to the higher number of gantries deployed across the berths. The section above presented the productivity capability at the different container terminals. The next section will present the actual performance observed at the three main container terminals.

5.2 Actual performance data

5.2.1 SWH and GCH (2014–2015)

Table 5.5 below shows a summary of the actual performance data obtained from a series of vessel performance reports of a major shipping line operating at the sample berths over a period of 12 months. The vessel performance reports outline the holistic vessel performance, mainly highlighting the average GCH and SWH achieved at the respective terminals against the set targets as well the delays experienced. During the period of the research, both the south and the north quay were undergoing repairs (April-July 2014 for the south quay, and September 2014-March 2015 for the north quay). However, an analysis could still be done on the average performance trend of the active months of operations.

Table 5.4: Actual average monthly SWH and GCH

PORT		TAR-GET	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
DCT	**GCH**	28	25	24.6	24.4	23.1	23.5	23.8	24.9	23.6	23.3	24.2	23.2	24.2
	SWH	62	68	62.3	67	52.6	52.6	52.9	58.3	60	55.3	52.1	58.1	60.6
South Quay	**GCH**	28					27	28.3	28	25	23	23.9	28	24.8
North Quay (205)	**GCH**	28	18.5	15.7	16.8	7	12							
North Quay (204)	**GCH**	28	25.1	26	25.1	24	24	21.9	25	25	26	25.6	26.5	24.9
North Quay (203)	**GCH**	28	24.1	23	23.7	22	22	23.3	23	22	22	23.4	23.6	23.2
East Quay	**GCH**	20	19.9	19.8	20.5	19.6	16.7	16.7	17	20.1	16.6	18.8	19.1	17.8
	SWH	43	46.6	38.4	32	43.3	49	44.5	40.4	48.8	50.9	48.1	47,6	44.2
NGQURA	**GCH**	30	25.3	22.4	19	21.3	25	25	28.4	25.4	26	29.5	28	22.9
	SWH	51	52.7	35.1	31.7	38.6	48.9	45.2	52.62	52	53.4	60	56	50.9
CTCT	**GCH**	32	34	35	32	32	32	32	30.6	32	28	30	32	31
	SWH	52	51	53	45	47	45	57	48	44	47	49.1	54.3	43.1

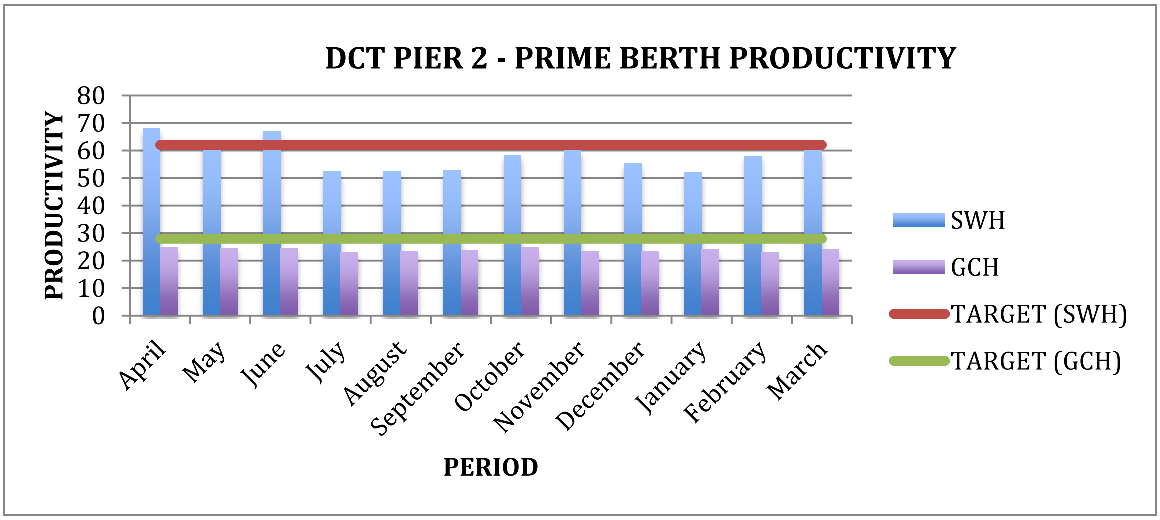
Source: Vessel performance report, 2014–2015

The port terminal's current averages on the GCH and the SWH show mixed sets of results and gaps when comparing the targets to the actual figures. The figures are for the period starting from the beginning of the financial year 2014 to March 2015. Table 5.4 indicates that DCT's productivity averages 24 crane moves an hour against the target of 28 moves on their prime berths, and an SWH of 58 moves against a target of 62. On the non-prime berth at DCT, the GCH averages 16 moves per hour against the target of 20 and SWH averages 42 moves, which is almost at the same level as the target. The CTCT shows an average GCH and SWH of 31.8 and 48 moves an hour respectively against a target of 32 and 52 moves an hour. NCT presented a GCH average of 26.8 moves an hour against a target of 30 and an SWH of 48 against a target of 51 moves an hour.

5.2.2 DCT Pier 2 productivity

For ease of reference and discussion, we will consider the average performance of DCT Pier 2, showing the overall average performance of the prime berths as indicated in Figure 5.2. The actual SWH had exceeded the targeted baseline for only three months of the year and remained below target during the other nine months, whereas the GCH remained below target for the entire 12-month period.

Figure 5.2: DCT Pier 2 prime berth productivity

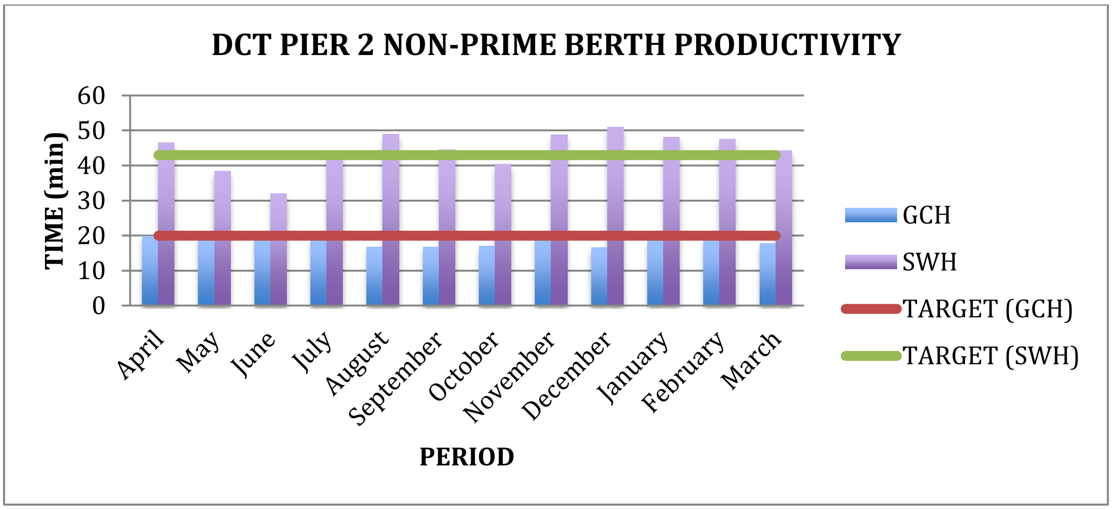


Over and above the reduced delays considered when setting the targeted GCH and SWH, it is clear from the results shown in Figure 5.2, that there are more underlying reasons for the low performance. Throughout the year the GCH remained below target. The levers impacting on the low performance include but are not limited to:

- Stevedore delays
- Hot seat changes
- Crane breakdown
- Unscheduled crane maintenance
- Straddle shortage

DCT Pier 2 achieved an SWH below target in all the months except April and June which had 68 and 67 moves an hour respectively. As stated above, the SWH considers all levers contributing towards productivity in totality, including the carrier's responsibility. In addition to what the operator has to deliver for increased productivity, it is the responsibility of the cargo interest to be timeous in the delivery and collecting of cargo in and out of the terminal as well to be precise regarding all stowage plans in order to avoid re-stows. From the analysed data, it appears that the reduced SWH at DCT Pier 2 comes as a result of equipment breakdown in the main as well the operator delays, which include shifts, hot seat changes and agent's delays. There has also been an increase in the average ship turnaround time from 53 hours in 2013 to 58 hours in 2014 (Transnet Audited Result, 2014).

Figure 5.3: DCT Pier 2 non-prime berth productivity



The GCH on the non-prime berth (Figure 5.3) has consistently been under the set target. This may be attributable to the age of the equipment used to operate the cargo, as stated above. The berth experienced equipment breakdowns and downtime. There were months, however, that showed a higher SWH and this was achieved as a result of crane intensity, operating a berth with three cranes instead of the normal two in order to acquire higher loading rates and turnaround times.

5.2.3 CTCT productivity

CTCT continues to deliver a favourable GCH averaging 31 moves per hour against a target of 32. This more favourable performance is largely due to the quayside superstructure being fairly new and experiencing fewer machinery breakdowns and downtime. The improved performance is also shown on the ship turnaround time, which reduced from 44 hours in 2013 to 29 hours in 2014 (Transnet Audited Results, 2014). The results also indicate that crane operations were done to full capacity and speed, in line with performance specification and standards, namely one move taking two minutes to complete.

Figure 5.4: CTCT productivity

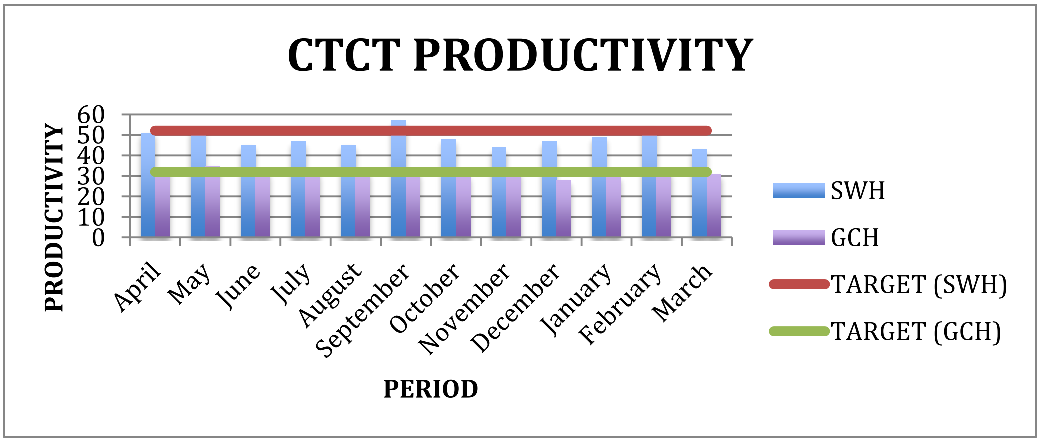


Figure 5.4 indicates, however, that CTCT achieved an SWH somewhat below the target baseline, averaging 48 moves against a target of 52. The reason for the low SWH is that the terminal has three active berths, equipped with eight gantries. Seven gantries generally service the three berths, as one gantry is out for routine planned maintenance schedules. As can be clearly seen, the crane density is thin to achieve a higher SWH, despite the good GCH.

5.2.4 NCT productivity

In the case of the port of Ngqura, the GCH and SWH performance has been below target, averaging 23 and 43 moves respectively.

Figure 5.5: NCT productivity

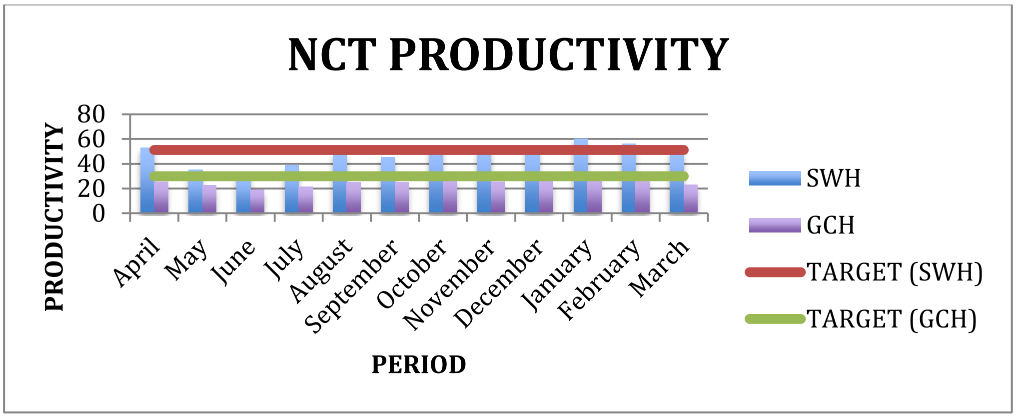


Figure 5.5 indicates that between April and June the SWH dropped below the target of 51 moves per hour but there was an apparent increase from July onwards. This low SWH may well be attributable to problems of unmatched quayside and landside equipment. The terminal crane capacity was increased from six to eight ship-to-shore cranes without adjusting the supporting landside fleet and labour capacity that stretched these limited resources to service the operations. From July onwards, the labour force was increased as was yard transportation and that resulted in the SWH increasing over time.

5.2.5 Truck turnaround time

The Truck turnaround time (TTT) is set by the operator at the same target for all container terminals in South Africa (35 minutes) and it is the baseline data used in analysing performance. TTT in Cape Town and Ngqura container terminals stood somehow below or roughly on target over the year (Table 5.6) averaging 17 and 34 minutes, respectively, against a target of 35 minutes. The shorter and favourable TTTs at CTCT and NCT are the result of smaller container yards, allowing for a smooth flow of landside transportation and shorter distances between the stacks and the main terminal gates.

Table 5.5: Average monthly TTT summary (2014–2015)

TTT	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
TARGET	35	35	35	35	35	35	35	35	35	35	35	35
DCT	**33**	**36**	**35**	**44**	**52**	**47**	**52**	**54**	**49**	**42**	**39**	**37**
TARGET	35	35	35	35	35	35	35	35	35	35	35	35
CTCT	**16**	**15**	**18**	**19**	**18**	**18**	**18**	**21**	**10**	**19**	**14**	**21**
TARGET	35	35	35	35	35	35	35	35	35	35	35	35
NCT	**38.8**	**37.6**	**35.6**	**35.3**	**36.2**	**34.6**	**34.4**	**33.4**	**32.4**	**35**	**34**	**37**

Source: TPT Consolidated Movement Report (CMR), 2014–2015

DCT has the highest TTT averaging 43 minutes against a set baseline of 35 minutes, in comparison to the other two container terminals. This is plausible because Durban is both the largest physical terminal and the main port handling higher volumes of cargo compared to Cape Town and Ngqura. There are a number of possible reasons for the high turnaround time at DCT. It could be that all the stacks are open at the same time to receive imports from four vessels simultaneously. Also, there are equipment shortages to handle incoming trucks with export cargo. Finally, the boxes must also move over greater distances to and from more distant stacks, because of the larger yard operations. The longer the TTTs, the higher the chance of a congested terminal, which might result in a less fluid terminal and longer queues outside the terminal gates.

Figure: 5.6: TTT for DCT, NCT, and CTCT

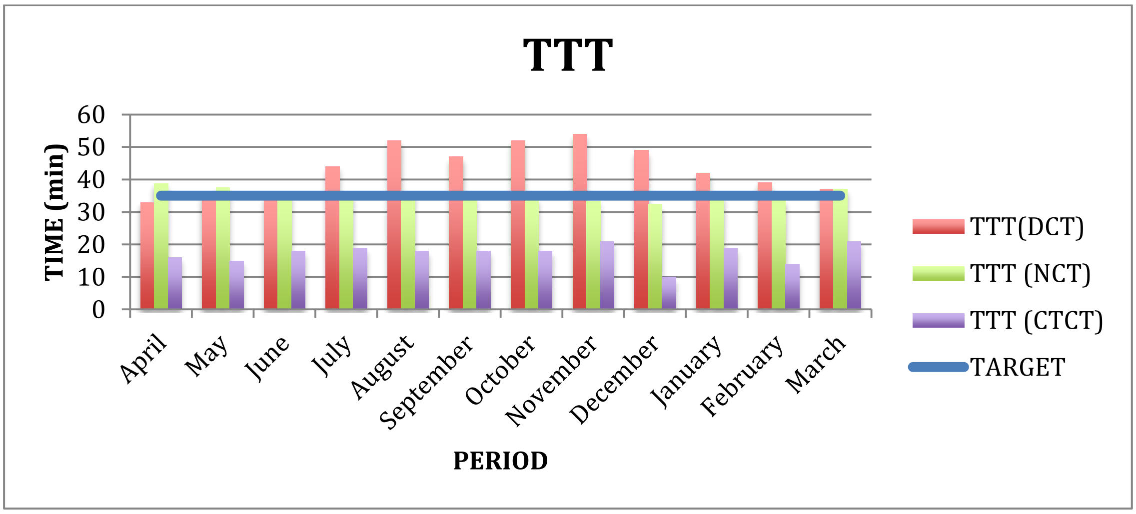


Figure 5.6 further depicts higher TTT between the months of October and December, associated with increased volumes and a seasonal peak period for higher economic activities, with the opposite happening after the peak months from January to March.

5.2.6 Dwell time

Dwell time figures provide a major commercial instrument that can be used to attract cargo and generate revenues for both the terminal operator and the port authorities. Table 5.6 shows the set target baseline for the dwell time permissible on all exports, imports and trans-shipment cargo at the three respective ports. For export cargo, the dwell time is set at a maximum of five days whereas imports are given a three-day allowance at the terminals. Trans-shipment dwell time is slightly higher in order to accommodate connections as well as reshuffling of trans-shipment cargo. The allowed free days for trans-shipment cargo are 10 days in Durban and 15 days in Cape Town and Ngqura. The lower dwell time targets in Durban could be attributed to the size of volume and scale the terminal handles, requiring faster clearance of cargo out of the terminal.

Table 5.6: Dwell time targets at Durban, Cape Town and Ngqura container terminals

Ports	Exports	Imports	Trans-shipments
Durban	5 days	3 days	10 days
Ngqura	5 days	3 days	15 days
Cape Town	5 days	3 days	15 days

Source: Transnet Integrated Report, 2015

According to Table 5.7, the average dwell time is generally good in all the container terminals and above target for imports and trans-shipment cargo. With regards to exports dwell time, both DCT and Cape Town show a slightly higher terminal stay for exports, above the set three free days. This could be because of the export stack opening only for three days and closing a day before a ship arrives. Should the ship be delayed, the export cargo will remain in stack for more than three days as discharge of the incoming cargo will be prioritised.

Table: 5.7: Average monthly dwell time summary for DCT Pier 2 and CTCT (2014–2015)

Dwell Time	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
DCT PIER 2												
IMPORT	1.67	2.03	1.55	1.68	1.92	1.92	1.81	1.81	2.16	1.96	1.6	1.68
EXPORT	4.94	5.11	5	4.93	4.81	6.15	6.04	5.83	5.94	6.28	6.38	5.58
TRANSHIP	5.65	5.8	6.96	6.09	8.75	8.5	7.49	5.73	6.85	7.37	6.19	5.39
CTCT												
IMPORT	1.95	2.1	1.8	1.8	1.8	1.63	2.42	1.98	2.1	2.68	2.23	2.43
EXPORT	3.86	3.87	5.4	5	4.7	5.27	5.15	4.11	5.4	5.51	4.06	4.81
TRANSHIP	7.04	5.34	7.2	5.1	6.7	7.01	6.96	5.34	9.1	7.27	6.09	6.04

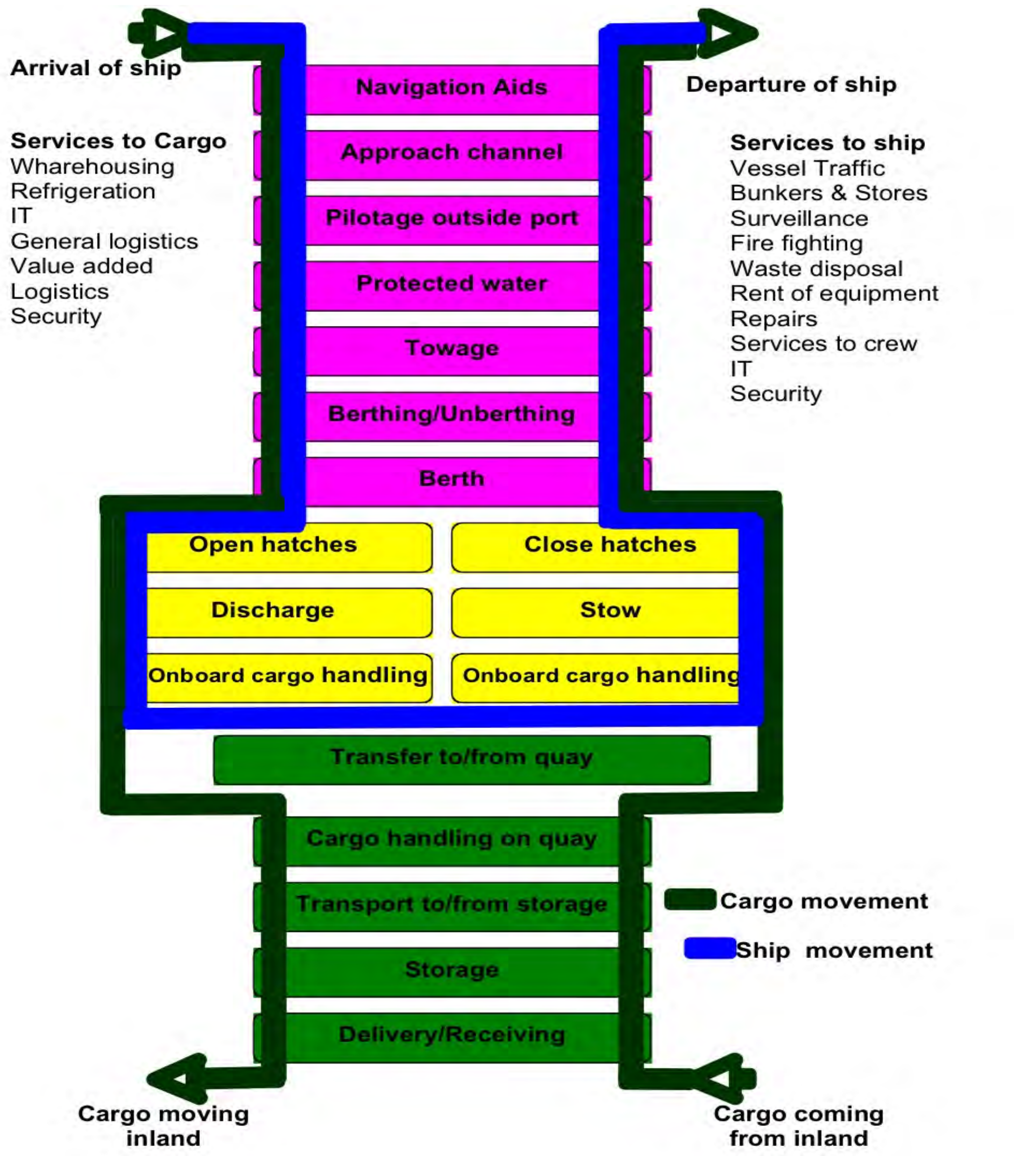
Source: TPT CMR, 2014–2015

Imports and trans-shipment cargoes are cleared out of the terminal within the set targets.

5.2.7 Total port turnaround time

Total port turnaround time is also one of the key indicators of port efficiency. The total port turnaround refers to the period between the times a vessel reports its arrival at the anchorage of the port up until the time it leaves the berth, outbound. The port turnaround time is made up of a series of events as indicated in Figure 5.7 which include marine services (tugs, navigational services and pilotage) as well as berth operations.

Figure 5.7: UNCTAD strategic port pricing – port value chain (1995)



Source: UNCTAD, 1975

Each event is subject to its own performance objectives, which might be impeded by certain factors including, but not limited to, extended waiting hours at anchor owing to berth unavailability, shortage of marine equipment, tardy pilot and tug services as well as a limitation of human resources required to operate equipment. These factors could lead to delays that would increase port stay and turnaround times. The port authority has set a target for the time a vessel spends at anchorage to a maximum of 46 hours (TNPA Corporate Strategy, 2014). APPENDIX 1 shows the longest stay at anchorage to be 117 hours at DCT for vessel type A. Longer anchorage stays are affected by a host of different factors, one being the carrier's deliberate instructions caused by delays from connection or late arrival of export cargo in stack. Emphasis on port turnaround time will therefore be placed on the quayside and landside productivity.

The argument of this dissertation is that the port turnaround times at the respective container terminals analysed may be shown to be inconsistent over time, given the available operations infrastructure. The CTCT turnaround time is generally acceptable, averaging two days as indicated in APPENDIX 1. The port authority has set the port turnaround target times at 57 hours for DCT and 45 hours for NCT (TNPA Corporate Strategy Report, 2014).

In arguing the above, the performance of two types of vessels calling the respective ports was tracked, in order to measure the actual turnaround times and inconsistencies (see APPENDIX 1). The two types of vessels, differing in call size and types of cranes required, were vessel type A (gearless, 4 000 TEUs handled per port call) and vessel type B (geared, 2 000 TEUs handled per port call). Only the turnaround time for the ports of Ngqura and Durban were analysed. The CMR shows a wide range of total port turnaround times from the longest stay of 172 hours at DCT to the shortest stay of 58 hours. In Ngqura, APPENDIX 1 indicates the longest stay of 156 hours and the shortest stay of 18 hours. In measuring trends and patterns of the port turnaround time at the respective terminals, a standard deviation (SD) method was applied to a sample consisting of over 40 observations. The SD approach was considered to be an appropriate tool to determine the inconsistencies and volatility on the turnaround time over the observed period, by way of establishing a variance against the mean/average turnaround values achieved (see APPENDIX 1). The mean referred to in this regard represents the average turnaround time achieved from the time the vessel arrives at anchorage, berths and finally leaves the port. The further away the SD is from a mean of zero the more inconsistent a particular performance is. A smaller SD is preferable as it means that the deviation is not far from the mean performance level with minimal inconsistencies. Sample observations are summarised in Table 5.7 below.

Table 5.7: Mean and standard deviation for DCT and NCT port turnaround times

VARIABLES	VESSEL A	VESSEL B
DCT – Pier 2		
MEAN (m)	101.1	86.8
STANDARD DEVIATION (SD)	25.4	51.2
NCT		
MEAN (m)	53.7	80.8
STANDARD DEVIATION (SD)	33.9	112.4

Source: TPT CMR, 2014–2015 (APPENDIX 1)

In the table above, vessel type A at DCT Pier 2 showed a mean of 101.1 hours of total port turnaround time with a SD of 25.4, showing some deviation from the mean levels of performance and somewhat inconsistent port turnaround. Vessel type B in DCT has even a higher SD, indicating greater inconsistency in the level of performance. NCT data shows a higher SD on vessel A's performance and an even bigger SD on vessel B's performance. In the case of NCT, the higher turnaround times and higher inconsistencies are not only the result of various moves done from the trans-shipment operations, but also tight trans-shipment transit times often caused by delayed inbound vessels, resulting in longer port stays and turnaround times. In addition, during the period under consideration, NCT experienced a low SWH owing to a lack of sufficient cranes and the supporting landside equipment and labour, adding to longer turnaround times.

In the case of DCT, most of the vessel A calls are on paid windows (CTOC, see Chapter 4) meaning that they are guaranteed a departure time on condition that the vessel arrives on schedule and does not exceed the number of contracted moves. Less time is spent at anchorage at an average of 26 hours, as the vessel's berthing is almost on arrival. The slight inconsistencies on the turnaround time result from the quayside and landside operations, for the reasons stated in the previous sections of this chapter, resulting in an average vessel turnaround of over 100 hours at berth. Vessel B calls do not have allocated windows, and only berth when there are berths available for them, seldom resulting in longer anchorage waiting time. APPENDIX 1 shows, however, that the longest anchorage waiting time reached was 136 hours, which is an exception as the most waiting time achieved was approximately between two to three days. The possible reason for the longer waiting time of six days or more could be that different vessels servicing same trades (and potentially requiring the same berths) arrive at almost at the same time without the shipping line having sufficient cargo to load on both of them. The longer turnaround time could also be due the usage of older cranes at the non-prime berth with lower SWH (20 moves per hour) as well as scheduled or unscheduled maintenance of (older) cranes and landside equipment.

Total port turnaround time is also a KPI of the port authority and it is measured in line with other variables including berth occupancy and berth utilisation. The berth occupancy rate represents the percentage of the total available time that ships occupy berths, and the berth utilisation rate is the percentage of the actual working time at berth. As discussed in Chapter 4, the berth occupancy should ideally be set such that there is always a berth available for ships to berth almost at arrival. Unduly high berth occupancy rates (as indicated in Table 5.8) are associated with longer waiting times, which in turn add to the vessel port turnaround time. In addition, the berth occupancy rate could be on target as well as the utilisation rate, but the quality of cargo handling might still affect the port turnaround time.

Table 5.8 below summarises the berth occupancy and utilisation rates at the respective ports together with their target and actual performance.

Table 5.8: Summary of the berth occupancy container terminals in South Africa

PORT	Berth occupancy - per cent		Berth Utilisation - per cent	
	Target	Actual	Target	Actual
Durban	70-80	81	70-80	78
Cape Town	60-70	66	50-60	62
Ngqura	75-85	77	75-85	84

Source: TNPA Corporate Strategy Report, 2014

All the container terminals have determined their berth occupancy targets with DCT having set their target at 70–80 per cent, CTCT having a target of 60–70 per cent and NCT having a target of 75–85 per cent, as shown in Table 5.8. The actual performance shows that Durban has recorded slightly higher average berth occupancy and this could be due to its main port status or its higher overall vessel traffic levels, leaving most berths spaces occupied almost all the time. Berth utilisation is also within target, indicating full and planned utilisation of the berths by the port authority. However, in the literature, De Monie expressed an opinion that even if both the berth occupancy and utilisation are within the set targets, it does not mean that the port turnaround time can be significantly reduced, since that efficiency still lies in the quality of cargo handling at the quayside. It is therefore clear from Table 5.8 that the container terminal requires improved quayside operations in order to deal with turnaround time challenges.

5.3 Benchmarking analysis of South African container terminals with ports of similar capacity and economic characteristics

In this context, benchmarking refers broadly to the comparison of performance of one port against another similar port to assess whether the same value is derived from similar operations. Benchmarking results will lead to a situation where improvement initiatives can be drawn in relation to best practice and enable the terminal operator to identify specific bottlenecks. For a benchmarking exercise related to container terminals, it is difficult to generate single, holistic terminal-wide metrics. When benchmarking, not all benchmarks will be suitable to the ports in question since the nature of performance requirements may be different. That said, container terminals are usually less diverse and have sufficient common themes to enable a benchmarking exercise to compare relative performance against other ports of similar capacity and industry standards.

In this dissertation, particular attention is given to criteria used in selecting the benchmark ports. The comparator ports are selected based on the similar amount of container traffic handled, the types of trade serviced as well as similar economic profiles, port layout, port characteristics, superstructure and landside equipment and related port operations dynamics. The four comparators cases selected are Tecon Santos (South America), Colombo (Sri Lanka), Melbourne (Australia) and the Mauritius Container Terminal (Port Louis, Mauritius). The container terminals of Tecon Santos and Melbourne are broadly comparable in terms of traffic volumes and vessel call types to the DCT, whereas the Colombo trans-shipment hub is similar to NCT.

5.3.1 Productivity benchmarks

A benchmarking productivity exercise at the abovementioned ports against that of South African ports will be based on the following parameters and themes:

- **Vessel performance measurement** – quay crane productivity (GCH), number of lifts per vessel hour (SWH), labour and delays.
- **Equipment measurements –** available and required equipment as well as equipment breakdowns and maintenance trends.
- **Yard performance measurement –** dwell time, TTT, stack management, yard equipment performance and rail turnaround time.

5.3.2 Productivity profiles of the benchmark ports

5.3.2.1 Tecon Santos Container Terminal

Tecon Santos, a business unit of Santos Brasil, is a container terminal operator under a long-term concession given by the government of Brazil at the Port of Santos. As in South Africa, the terminal is part of a "landlord port" structure, whereby the domain of the port authority is restricted to the provision of the infrastructure, while the investment in the superstructure and terminal operation is the responsibility of the licensed operator. Tecon Santos is a leader in operational efficiency and modernity consisting of a total area of 596 000 square metres and it is located at the biggest port in Brazil recording up to 110 container moves per hour in 2014 (Sustainability Report, Santos Brazil, 2014). Truck turnaround time at Tecon is less than 30 minutes and a GCH of 35 moves per hour have been achieved. It is Latin America's biggest container terminal and handles 37.6 per cent of Brazilian trade (Annual Report of the Sao Paulo State Docks Company, CODESP, 2015). The annual throughput capacity at Tecon Santos is two million TEUs, accounting for a total market share of 33 per cent of container handling at the Port of Santos, which has three other container terminals. Tecon consists of its own quay wall of 980 metres, formed by three mooring berths in addition to a fourth berth of 310 metres that may also be used for both automotive and container vessel operations. The berths are equipped with a total of 13 quay cranes, six of which are the latest generation, capable of handling the world's biggest vessels (the ultra-large container ships). The quay superstructure is supported by a total of 44

RTGs and 22 reach stackers.

Tecon Santos is in a position to achieve and maintain these high levels of productivity as a result of having more cranes achieving an average of 1.5 moves per minute as compared to the two moves per minute in South Africa. The large number of cranes deployed at each berth generated average SWH of 110 moves per hour. Each berth is operated by at least four gantry cranes during loading and unloading of containers. Tecon uses a modern container-positioning system via GPS as well as the most advanced port software application in the world, Navis, providing greater operating efficiency. Similarly, the RTG operations at Tecon Santos can be compared to those of the CTCT, with Tecon using RTGs to optimise storage space in response to stacking space limitations.

5.3.2.2 Port of Colombo

The Port of Colombo is run by the Sri Lanka Ports Authority, which is a statutory corporation established under the Sri Lanka Port Authority Act of Parliament (Wikipedia). Colombo Port follows predominantly a public service port model, whereby the port authority owns and operates all assets and carries out all cargo handling activities directly. The Port of Colombo consists of three container terminals: Jaya Container Terminal (JCT), South Asia Gateway Terminal (SAGT) and Unity Container Terminal (UCT). The total annual throughput amounts to 4.26 million TEUs and it is regarded as a trans-shipment hub in South Asia for cargo moving from the East to West trades and vice versa, with trans-shipment volumes accounting for up to 74 per cent of container traffic (Public Policy and Markets Building: Container Operations at Colombo port, 2012). For this benchmarking exercise, the SAGT, which accounts for a throughput of 1.9 million TEUs annually, will be used as part of the sample, as its port system model is broadly similar to that of NCT.

SAGT consists of three container main berths with a quay wall of 940 metres and a maximum draft of 15.0 metres. The terminal consists of nine super-post-panamax quayside cranes, with twin-lift capabilities; three post-panamax quay cranes, 31 RTG cranes and two reach stackers. To date, SAGT has recorded a productivity level of a GCH of 34 moves per hour and an SWH of 75 moves per hour (Journal of Commerce

USA, 2015). Eighty per cent of SAGT's business consists of trans-shipment container traffic and it remains one of the preferred trans-shipment hubs in South Asia. The high productivity levels at SAGT are a result of the increased number of cranes deployed across the berths. With 12 cranes in service, each berth is serviced by at least four cranes, resulting in high SWH levels. The high GCH is also the effect of a combination of generous quayside equipment availability and efficient crane utilisation rates of about 1.8 minutes per move, compared to the two minutes it takes in South Africa to move one container.

5.3.2.3 Mauritius Container Terminal

Container cargo at the Mauritius Container Terminal (MCT) in Port Louis is handled by the state-owned Cargo Handling Corporation Limited (CHCL) and supervised by the Mauritius Ports Authority under a concession contract. The MCT occupies a quay of 560 metres, consisting of two berths with 14 metres alongside depth. The MCT has an annual container throughput of 550 000 TEUs including trans-shipments (Cargo Handling Corporation Limited, 2014). The terminal is equipped with five post-panamax ship-to-shore gantry cranes, eight RTG cranes, twelve reach stackers, 37 tractors and a Navis operating system. Productivity at MCT averages 20 moves per crane hour.

5.3.2.3 Melbourne Container Terminal

The Port of Melbourne is Australia's busiest container port terminal handling 36 per cent of the nation's container trade, with a total annual container throughput of 2.5 million TEUs (Port of Melbourne Annual Report, 2013/14). At the Port of Melbourne, similar to the Port of Durban, containers account for up to 70 per cent of the port's total trade. The port operates two international container terminals: the Swanson Dock East (SDE) and West as well as the Webb Dock East. SDE consists of three berths on a quay wall of 885 metres, with a water depth of 12 metres, eight post-panamax cranes and 49 straddle carriers (Patrick Terminal Annual Report, 2014). The fourth berth is at Swanson Dock West, 994 metres long with 11 post-panamax cranes and 38 straddle carriers. The Port of Melbourne achieves average GCH levels of 22 to 30 moves per hour, SWH of 67 moves per hour and average dwell time of three days, as indicated in the annual report. In Melbourne, the concept of crane intensity is applied and it involves the deployment of an increased number of cranes, between four to five cranes, to a single berth in order to maximise the ship-working rate (Lubulwa, 2010).

5.4 Performance summary of the benchmark ports

In terms of volume throughput across the benchmark ports, Durban has the highest container traffic at 2.9 million TEUs per annum, followed by Melbourne container terminal at 2.5 million, Tecon Santos at two million, Port of Colombo at 1.9 million, CTCT at 900 000, NCT at 800 000 and Mauritius container terminal at 550 000 TEUs per annum, as shown in Figure 5.8 below.

Figure 5.8: Annual container throughput of benchmark ports

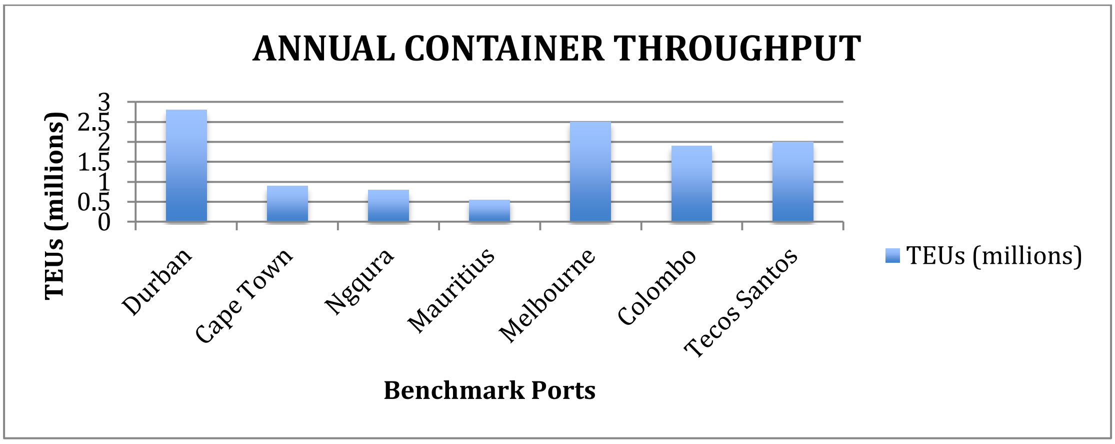


Figure 5.8 also indicates that the container terminals of Tecon Santos and Melbourne are broadly comparable in terms of traffic volumes and vessel call types to the DCT, whereas the port of Colombo and Mauritius container terminal, as trans-shipment hubs, are broadly similar to NCT, with Colombo topping the list on trans-shipment volume traffic.

In terms of vessel performance measurements on all benchmark ports, Table 5.9 indicates that Tecon Santos records the highest rates of productivity at berth achieving an SWH of 110 moves per hour. This level of efficiency may well be as a result of the 16 cranes deployed to the berths indicating some level of crane intensity used to achieve high quayside productivity as well as the efficient use of the landside equipment and resources in achieving the maximum SWH.

Table 5.9: Summary of the port productivity of benchmark ports measured in SWH and GCH

PORT	GCH	SWH	Berths	Cranes
DCT Pier 2 (Prime Berth)	24	58	3	8
Cape Town Container Terminal	31	48	4	9
Ngqura Container Terminal	27	48	4	10
Tecon Santos	35	110	3	13
Mauritius Container Terminal	21	40	2	5
Port of Melbourne (SDE)	26	67	3	8
Port of Colombo (SAGT)	34	75	3	9

By comparison, in the prime berths at DCT Pier 2, a maximum number of three cranes may be deployed at each berth (with at least four straddle carriers), which translates into a GCH of 30 moves an hour and an SWH of 90 moves an hour, with fewer delays. In addition, the normal productivity for a traditional container terminal with conventional single-lift quayside cranes is between 20 to 25 crane moves per ship-operating hour and 30 to 32 moves for a twin-lift crane (Benchmarking Container Terminal Performance Report, 2003). Durban, however, is still averaging 24 to 25 moves an hour, even with the deployment of the new tandem lift ship-to-shore gantry cranes. The equipment is expected to deliver higher productivity levels, with a design capacity of lifting two 40-foot containers and four 20-foot containers in tandem and can reach 24 containers across the vessel and seven containers high above deck. The forecasted performance level of the new cranes is a product of a GCH of 33 moves per hour compared to the current average of 24 moves per hour, and a SWH of 85 moves per hour compared to the current 58 moves (SAnews.gov.za).

The SDE container terminal at the Port of Melbourne, which has a similar annual container throughput as DCT, has a similar productivity level as DCT Pier 2, averaging a GCH of 25 moves an hour and within the industry norm. However, the SDE has a smaller number of berths and fewer cranes in their operation compared to DCT, but deploy these cranes differently in order to maximise productivity and efficiency by deploying the crane intensity strategy.

From a trans-shipment point of view, the Port of Colombo and NCT have similar characteristics on quayside layout, draft and equipment deployment. The SAGT and NCT have annual container trans-shipment traffic of 1.9 million TEUs and 800 000 TEUs respectively, with NCT having planned investments that will ramp up terminal capacity to two million TEUs over the next three years. Both terminals have similar crane performance with NCT averaging a GCH of 32 and SAGT averaging a GCH of 34. The only different observation was on the part of the SWH, with SAGT averaging 75 moves per hour and NCT averaging only 54 moves an hour. As mentioned above, the low SWH in NCT occurs because the quayside superstructure was increased without having a complementary landside handling capacity and relevant resources.

On yard performance, South African container port terminals operations have fairly good yard utilisation and this is seen through the deployment of different yard equipment at different terminals according to their respective characteristics. CTCT is characterised by limited stacking space and is operated with RTGs with high density stacking techniques of four to five stack heights. The DCT is, however, characterised by a much larger yard area, allowing for straddle carrier operations with stack heights of three to four high. The yard productivity at NCT proved to be low because of insufficient yard equipment to match the quayside operation's capacity. The number of cranes deployed to load and unload cargo did not have complementing yard equipment to handle the cargo and this resulted in productivity slowing down, leading to slower yard productivity as well as longer anchorage waiting times. Tecon Santos, even with its space limitation, successfully utilises RTG operations in complementing its high crane productivity.

The dwell time for containers between the point of discharge and dispatch in the terminal serves as a good means to identify poor clearing procedures and is a good benchmark to be used in order to improve yard cargo clearance. The average time set as a target in most container terminals is a dwell time of between three to four days. Exceeding this stipulated time will result in punitive storage charges (TPT, Standard Operating Procedures). In practice, typical averages of between five and seven days are usually considered reasonable. In South African container ports terminal the average dwell time is three to four days, with CTCT showing even shorter dwell times of up to a day and a half against a target of three to four days, as seen in table 5.7 above. Dwell times at the Port of Melbourne average three days. Container port terminals with higher annual throughput (DCT, SAGT, Tecon Santos and SDE) generate time profiles that are within the industry average of three to four days.

The time that a truck takes within a terminal to discharge or uplift a container (TTT), is another standard measure of efficiency of gate and yard operations. Generally, a period of between 25 and 30 minutes (Beckett Rankine Partnership, 2003) from entry to exit is considered acceptable. In South Africa the target TTT is 35 minutes but the terminals have achieved average truck turnarounds of 17 to 34 minutes, which is deemed reasonable compared to the global average. However, the TTT in the terminal is of little concern to shippers if the truck becomes stuck in traffic outside the gates of the terminal causing delays and possibly missing pre-assigned collection delivery windows. This is a vital for the terminal business, although the terminal operator has little control over it.

From the above benchmarking exercise, it can be seen that South African container terminals with their different annual throughput volumes are performing fairly well with productivity levels comparable with other similar ports. However, the exercise has demonstrated that room for improvement exists in quayside operations insofar as optimum crane utilisation is concerned, as well as workforce enhancement in support of the available infrastructure. Port productivity levels using the deployed cranes are within global averages of GCH of 28 moves per hour and SWH of 67 moves per hour. The dwell time and TTT are within the global averages of three days and 17 to 34 minutes respectively.

The next chapter will set out a conclusion as well as recommendations that might be useful in responding to the gaps and opportunities identified in this chapter.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

The overriding purpose of this study was to develop some further understanding of the actual performance capabilities of the South African container terminals, given the current infrastructure. The literature review conducted for this dissertation demonstrated different views and opinions on the0 importance of the correct parameters used globally to measure productivity as well as factors impacting productivity and performance at container terminals. The South African container terminal narrative, although aligned with global productivity objectives, is still confronted with several challenges that directly impact on the level of productivity. The desktop analysis conducted for this research was therefore used to bring out the underlying elements impacting on the performance together with some pockets of best practice from other similar ports with similar container traffic and trades.

In analyzing the 12-month data on productivity of the selected sample, the results indicated that the port terminal operator has been delivering productivity levels that range from lower-than-targeted gross crane moves per hour and ship working hour to a slight above-target performance on some months. Durban container terminal Pier 2 achieved an average GCH of 22 moves an hour against the target of 28 moves on prime berths and SWH of 58 moves against a target of 62. On the non-prime berths, the average GCH achieved is at 16 moves per hour against the target of 20 with an SWH averaging 42 moves, which is almost at the same level as the target. The GCH and SWH performance at NCT has been below target averaging 23 and 43 moves respectively with CTCT continuing to deliver a favourable GCH averaging 31 moves per hour against a target of 32.

The analysis placed effort on determining the actual potential of the deployed cranes in relations to the berths size and the landside capacity, in order to measure the underlying productivity capability of the infrastructure. Using standard crane specifications from the original equipment manufacturers (OEM), it should take a crane two minutes to move a single container and this measure converts into a GCH of 30 moves/hr. The study also showed that with the number of cranes available at the terminals under normal operating conditions, a maximum of three cranes could be deployed per vessel, which should give an SWH of 90 moves/hr. This productivity, however, has not been achieved in practice and the lower performance of both parameters is understood to be attributable to the following causes:

- Equipment breakdown;
- Aged equipment;
- Weather interruptions;
- Agents/carriers delays – hatch cover removal, re-stows, and vessel connections;
- Administrative delays including shift changes and worksheets exchanges; and
- Delays due to improper housekeeping.

The dwell time and truck turnaround times in all container terminals are well within the given baseline of between three to ten days for exports, imports and transshipments, respectively.

The study further highlighted the performance limitations attached to the total port turnaround time, which is made up of a sequence of events from the time the vessel arrives at anchorage until the time the vessel leaves the berth. The set anchorage waiting time target of between 45 and 50 hours, by the port authority, was not always achieved due to a host of reasons that are either in or outside its control. It was found that the shipping lines do contribute to the longer anchorage waiting time as a result of them wanting to meet some of their transshipment connections and to accommodate late exports coming into the port. Another contributing aspect to the port turnaround time, though to a much less significant extent, is the marine service portion, which is subject to delays emanating from tardy pilot and tug services and may contribute somewhat to longer port stays. Lower productivity levels at the quayside also contributed to the total port stays as indicated in the previous chapter. However, the total port turnaround time varied throughout the period analyzed from 28 to 156 hours, which led the analysis to measure the extent of the port turnaround inconsistencies. The standard deviation methodology calculated the levels of variations from the mean turnaround times for two types of vessels in DCT Pier 2 and NCT. Both exercises showed a large deviation from the average time and this was a clear indication of the dynamism of the port performances together with its inconsistencies. The port of Cape Town maintained a favourable turnaround time at the container terminal, during the period of analysis. Berth occupancy and utilization rates were well within the set targets determined by the ports authority; however, the quality of handling cargo was still a limitation and a point of concern the study kept its focus on.

The benchmark exercise indicated some pockets of excellence in terms of improving productivity. The port of Melbourne and Brazil's Tecon Santos demonstrated the usefulness and value of crane intensity, which can greatly increase the ship working hour rate.

Recommendations

In order for a container terminal to achieve higher container crane (GCH) output, the state of the cranes, together with their landside support infrastructure, needs to be technically and mechanically sound at all times. The onus lies with the terminal operator to put more emphasis on reducing equipment downtime and concentrate on improving the level of adherence to maintenance schedules and reduce unplanned and *ad hoc* maintenance on cranes.

In DCT, specifically the newly-deployed tandem lift ship-to-shore gantry cranes would need to be utilized at full capacity in order to attain crane productivity of 35 moves an hour in comparison to the 28 currently achieved. This includes the implementation of twin- and the quart-lift capacity where applicable. The twin lifts allow the container gantry to carry two 40-foot containers in a single lift and the quart capability allows for four 20-foot containers to be carried on or off the ship on a single lift. In this way the cranes are used to full capacity, positively influencing the number of moves that can be achieved in an hour. In addition, the GCH can be improved by maintaining the quality of the yard and waterside planning; investing in more straddle carriers to support the crane infrastructure, receiving correct stowage plans from the carriers, alignment between the port operator and stevedoring companies as well as a highly skilled and trained labour force.

Another option is to consider implementing dual-cycling operation, which refers to the simultaneous loading and unloading of ships in order to optimize the efficiency of quay cranes, increase productivity and shorten vessel turnaround. This option will, however, require the port operator to put different strategies in place as far as scheduling of the loading and discharging is concerned, the landside equipment and space supporting the dual-cycling as well as congestion management on the landside.

The concept of crane intensity, which refers to increasing crane deployment across vessels in order to increase the SWH and vessel turnaround times, should be the goal of the operator. The literature review emphasized the importance of efficiency in making sure that the ports achieve a reasonable return on investment. The KPIs adopted by the South African ports systems on the container trade do align with global best practice. However, the dissertation analysis has caste some light on the importance of how more as well as improved strategies for the utilization of infrastructure and resources are critical in achieving optimal performance. On labour challenges, supervision of shift changeovers should be closely monitored in order to reduce idle time between shifts. Improvements on the level of training by the operator to quayside and landside personnel, should take precedence so as to match the skills in accordance with the existing infrastructure. In the case of the Port of Ngqura and its related productivity, this research has highlighted the need for the operator to always ensure matching quayside and landside equipment together with available resources in order for the terminal to achieve higher efficiencies and avoid unnecessary delays.

The formula of improving port productivity should therefore be premised on the port terminal operator receiving timely and accurate information from the carriers about the container stowage on its vessel at least 24 hours before the arrival of the vessel. Port productivity places a shared challenge to both the terminal operator and the carriers. Getting the formula right is one thing; the actual challenge is putting all the formula elements together to produce superior productivity levels i.e. vessel stowage, vessel size, volumes to be loaded and unloaded, the skills of the crane operator and other dockworkers, the cranes and other assets deployed in working the vessel and the price the carrier is prepared to pay for the services received from the terminal operator.

On optimizing yard operations, the efficient operations of straddle carriers through prime routing will allow for minimal waiting time by dropping the container at the nearest available crane rather that the designated crane, maximize terminal productivity and minimize human errors caused by straddle carrier drivers. A skilled and motivated workforce is imperative for a highly efficient terminal and the operator would need to place more emphasis in aligning the quality of the workforce with the anticipated performance targets and volumes. The other option is to work on redesigning the layout of the terminal to optimize landside operations. The way in which the terminal is laid out can increase terminal capacity, reduce the time taken by landside transportation and thus reduce the turnaround time of ships significantly. The enhanced terminal layout will also work well in transshipment terminals in order to maximize the use of the allocated stacking space so that there is minimal reshuffling of boxes thus increasing productivity and improving on efficiencies. This, however, calls for a further need to research how a port terminal layout design could influence productivity in an optimal way possible.

Container port terminals form part of the modern economy and the container revolution is far from its full maturation. The success of the shipping industry relies on cost and on the level of port efficiency, which is an important factor in determining a terminal's international competitiveness. The largely reduced cost derived from containerization means that the handling of goods has become highly automated and efficient between most transport modes and transporting goods anywhere around the globe has therefore become a feasible operation of many enterprises (Levinson, 2008). Containerization still remains an important factor in global trade and it is said to have a stronger impact in driving globalization than trade liberalization (UNCTAD Review of Maritime Transport 2014).

As stated above, the world container port throughput surpassed the 650 million TEU mark, from 601.8 million TEUs in 2012 to 651.1 million TEUs in 2013, making the container trade the fastest-growing maritime cargo segment. The expectations about future growth of containerized traffic will have to be matched with the physical reality of transport infrastructure. Thus, future developments for container terminals and their infrastructure will need to be geared more towards throughput maximization than capacity. For many container terminals, handling and maintaining the global container throughput will require the port performance to align with volumes passing through the terminal in order to meet the demand. In short, ports have to deal with both more as well as bigger container vessels requiring improvements of existing terminal facilities, infrastructure and technology to meet the growing demand. With respect to this evolution, container terminals are assigned an increasingly important role as key hubs within the overall transportation network.

The South African container terminals have therefore a potential to overcome productivity challenges with the existing capacity and infrastructure. There is a need for a major paradigm shift by the operator and its management together with a consideration of possible labour reforms required in order for the labour force to better embrace productivity and achieve desired levels of performance and efficiency.

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AN ASSESSMENT OF PORT PRODUCTIVITY AT SOUTH AFRICAN CONTAINER PORT TERMINALS

by

Innocentia IG Motau

213572290

A dissertation submitted in fulfilment of the requirements of the degree of Master of Commerce

School of Accounting, Economics and Finance
College of Law and Management Studies

Supervisor: Professor T Jones

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Appendix

DCT Pier 2 - VESSEL A
DESCRIPTION: 4500 - 5000 TEUs (gearless)

DATE	VESSEL ARRIVAL	BERTH ARRIVAL	VESSEL COMMENCE	VESSEL COMPLETES
Dec-13	31/12/13 19:18 Tue	03/01/14 00:48 Fri	03/01/14 02:20 Fri	06/01/14 09:35 Mon
Jan-14	07/01/14 18:30 Tue	07/01/14 20:00 Tue	08/01/14 00:01 Wed	10/01/14 01:45 Fri
Jan-14	15/01/14 03:20 Wed	15/01/14 09:36 Wed	15/01/14 12:30 Wed	19/01/14 17:15 Sun
Jan-14	22/01/14 02:10 Wed	22/01/14 03:48 Wed	22/01/14 08:00 Wed	26/01/14 03:00 Sun
Jan-14	29/01/14 07:20 Wed	30/01/14 04:30 Thu	30/01/14 09:30 Thu	02/02/14 05:25 Sun
Feb-14	05/02/14 05:00 Wed	05/02/14 09:00 Wed	05/02/14 11:00 Wed	07/02/14 21:00 Fri
Feb-14	09/02/14 23:00 Sun	10/02/14 02:48 Mon	10/02/14 07:30 Mon	14/02/14 17:30 Fri
Feb-14	11/02/14 07:35 Tue	13/02/14 02:18 Thu	13/02/14 04:00 Thu	16/02/14 08:00 Sun
Feb-14	20/02/14 02:30 Thu	20/02/14 09:00 Thu	20/02/14 10:30 Thu	23/02/14 06:30 Sun
Mar-14	04/03/14 13:00 Tue	04/03/14 15:12 Tue	04/03/14 16:30 Tue	07/03/14 10:40 Fri
Mar-14	12/03/14 06:00 Wed	12/03/14 13:30 Wed	12/03/14 20:25 Wed	16/03/14 09:40 Sun
Mar-14	18/03/14 04:00 Tue	18/03/14 08:42 Tue	18/03/14 10:30 Tue	21/03/14 04:00 Fri
Mar-14	31/03/14 11:00 Mon	31/03/14 13:36 Mon	31/03/14 16:00 Mon	04/04/14 22:30 Fri
Apr-14	02/04/14 13:00 Wed	02/04/14 22:43 Wed	03/04/14 00:30 Thu	05/04/14 10:30 Sat
Apr-14	06/04/14 08:00 Sun	08/04/14 11:00 Tue	08/04/14 12:00 Tue	11/04/14 01:50 Fri
Apr-14	14/04/14 05:30 Mon	14/04/14 13:00 Mon	14/04/14 15:15 Mon	18/04/14 08:35 Fri
Apr-14	20/04/14 09:50 Sun	20/04/14 22:18 Sun	21/04/14 00:01 Mon	25/04/14 16:00 Fri
May-14	05/05/14 06:00 Mon	08/05/14 02:48 Thu	08/05/14 08:00 Thu	10/05/14 23:30 Sat
May-14	13/05/14 10:00 Tue	13/05/14 21:42 Tue	13/05/14 23:30 Tue	16/05/14 10:40 Fri
May-14	19/05/14 21:00 Mon	20/05/14 00:30 Tue	20/05/14 02:30 Tue	24/05/14 04:40 Sat
May-14	30/05/14 03:30 Fri	30/05/14 05:24 Fri	30/05/14 08:00 Fri	01/06/14 14:00 Sun
Jun-14	04/06/14 09:00 Wed	04/06/14 11:18 Wed	04/06/14 12:40 Wed	07/06/14 03:15 Sat
Jun-14	18/06/14 17:35 Wed	18/06/14 20:48 Wed	18/06/14 23:30 Wed	22/06/14 03:00 Sun
Jun-14	26/06/14 05:00 Thu	26/06/14 16:06 Thu	26/06/14 17:30 Thu	29/06/14 20:00 Sun
Jun-14	01/07/14 10:20 Tue	02/07/14 21:00 Wed	02/07/14 23:00 Wed	05/07/14 13:40 Sat
Jul-14	08/07/14 18:10 Tue	10/07/14 13:00 Thu	10/07/14 15:15 Thu	13/07/14 14:00 Sun
Jul-14	15/07/14 11:00 Tue	17/07/14 23:06 Thu	18/07/14 01:00 Fri	22/07/14 12:50 Tue
Jul-14	26/07/14 05:00 Sat	26/07/14 11:48 Sat	26/07/14 13:25 Sat	30/07/14 12:30 Wed
Jul-14	29/07/14 14:30 Tue	31/07/14 21:30 Thu	31/07/14 23:20 Thu	03/08/14 16:01 Sun

Aug-14	05/08/14 05:30 Tue	06/08/14 09:48 Wed	06/08/14 11:00 Wed	10/08/14 10:45 Sun
Aug-14	12/08/14 11:45 Tue	12/08/14 22:23 Tue	13/08/14 00:15 Wed	16/08/14 20:30 Sat
Aug-14	13/08/14 13:20 Wed	16/08/14 08:18 Sat	16/08/14 10:20 Sat	18/08/14 23:59 Mon
Aug-14	18/08/14 23:59 Mon	19/08/14 02:24 Tue	19/08/14 08:00 Tue	22/08/14 17:00 Fri
Sep-14	23/09/14 15:30 Tue	25/09/14 15:18 Thu	25/09/14 17:00 Thu	29/09/14 04:30 Mon
Sep-14	29/09/14 17:20 Mon	04/10/14 09:48 Sat	04/10/14 11:00 Sat	06/10/14 03:50 Mon
Sep-14	02/10/14 07:00 Thu	02/10/14 23:54 Thu	03/10/14 03:00 Fri	05/10/14 15:00 Sun
Oct-14	08/10/14 04:30 Wed	08/10/14 22:00 Wed	09/10/14 01:00 Thu	11/10/14 06:00 Sat
Oct-14	14/10/14 04:40 Tue	14/10/14 12:30 Tue	14/10/14 15:30 Tue	17/10/14 11:30 Fri
Oct-14	21/10/14 05:30 Tue	21/10/14 08:18 Tue	21/10/14 10:00 Tue	24/10/14 17:30 Fri
Oct-14	28/10/14 18:00 Tue	28/10/14 21:30 Tue	29/10/14 00:01 Wed	01/11/14 08:35 Sat
Nov-14	04/11/14 18:00 Tue	04/11/14 22:30 Tue	05/11/14 00:01 Wed	07/11/14 20:00 Fri
Nov-14	10/11/14 15:42 Mon	11/11/14 05:24 Tue	11/11/14 08:00 Tue	14/11/14 07:00 Fri
Nov-14	19/11/14 18:00 Wed	19/11/14 23:00 Wed	20/11/14 00:35 Thu	22/11/14 22:00 Sat
Nov-14	26/11/14 17:10 Wed	27/11/14 02:18 Thu	27/11/14 03:30 Thu	30/11/14 03:25 Sun
Dec-14	10/12/14 05:50 Wed	10/12/14 10:30 Wed	10/12/14 12:00 Wed	14/12/14 13:00 Sun
Dec-14	16/12/14 16:40 Tue	17/12/14 11:42 Wed	17/12/14 15:00 Wed	20/12/14 03:00 Sat
Dec-14	29/12/14 16:09 Mon	31/12/14 04:06 Wed	31/12/14 07:30 Wed	04/01/15 06:45 Sun
Dec-14	01/01/15 22:10 Thu	01/01/15 23:18 Thu	02/01/15 16:00 Fri	07/01/15 05:00 Wed
Jan-15	06/01/15 11:05 Tue	08/01/15 16:36 Thu	08/01/15 18:30 Thu	11/01/15 12:20 Sun
Jan-15	13/01/15 18:00 Tue	14/01/15 21:36 Wed	14/01/15 23:30 Wed	17/01/15 14:45 Sat
Jan-15	20/01/15 20:30 Tue	20/01/15 22:12 Tue	21/01/15 00:30 Wed	24/01/15 12:50 Sat
Jan-15	28/01/15 03:30 Wed	28/01/15 12:12 Wed	28/01/15 15:20 Wed	31/01/15 06:20 Sat

VESSEL SAILS	VESSEL TURAROUND TIME (hrs)	ANCHOR (hrs)	TOTAL TURNAROUND TIME (hrs)	SWH
06/01/14 10:54 Mon	79	56	135	55.5
10/01/14 04:30 Fri	50	8	58	80.8
19/01/14 19:00 Sun	101	11	112	58.2
26/01/14 04:30 Sun	91	7	98	58.2
02/02/14 07:12 Sun	68	28	96	58.8
07/02/14 22:00 Fri	58	7	65	65.1
14/02/14 18:54 Fri	106	10	116	60.6
16/02/14 08:42 Sun	76	45	121	63.1
23/02/14 09:18 Sun	68	11	79	60.7
07/03/14 13:18 Fri	66	6	72	58.2
16/03/14 10:18 Sun	85	15	100	65.2
21/03/14 08:12 Fri	65	11	76	59.8
04/04/14 23:54 Fri	103	6	109	54.2
05/04/14 13:30 Sat	58	15	73	65.5
11/04/14 03:06 Fri	62	53	115	68.3
18/04/14 09:48 Fri	89	11	100	67.2
25/04/14 16:36 Fri	112	15	127	58.8
11/05/14 01:24 Sun	63	76	139	67.9
16/05/14 12:30 Fri	59	15	74	73.1
24/05/14 19:10 Sat	98	20	118	44.1
01/06/14 15:48 Sun	54	6	60	90.5
07/06/14 04:30 Sat	63	5	68	56.2
22/06/14 04:24 Sun	76	7	83	61.6
29/06/14 21:36 Sun	75	14	89	69.3
05/07/14 16:00 Sat	63	39	102	63.5
13/07/14 15:06 Sun	71	46	117	64.7
22/07/14 14:48 Tue	108	64	172	51.1
30/07/14 15:24 Wed	95	11	106	54.3
03/08/14 19:12 Sun	65	60	125	61.3

10/08/14 12:42 Sun	96	31	127	53
16/08/14 21:42 Sat	92	14	106	49.6
19/08/14 01:06 Tue	62	70	132	60.1
22/08/14 18:54 Fri	81	10	91	57.5
29/09/14 07:54 Mon	83	53	136	54.5
06/10/14 07:06 Mon	41	117	158	63.3
05/10/14 19:20 Sun	60	24	84	65.3
11/10/14 08:42 Sat	53	23	76	68.3
17/10/14 19:12 Fri	68	19	87	62.9
24/10/14 19:06 Fri	80	6	86	61.7
01/11/14 09:54 Sat	81	7	88	61.5
07/11/14 21:30 Fri	68	8	76	66.9
14/11/14 07:42 Fri	71	17	88	63.5
22/11/14 23:18 Sat	69	8	77	52.2
30/11/14 04:54 Sun	72	12	84	50.9
14/12/14 14:12 Sun	97	7	104	47.7
20/12/14 09:42 Sat	60	29	89	57
04/01/15 08:36 Sun	95	41	136	37.4
07/01/15 07:54 Wed	109	21	130	47.8
11/01/15 14:00 Sun	66	57	123	57.9
17/01/15 20:18 Sat	63	35	98	62
24/01/15 14:30 Sat	84	6	90	48.4
31/01/15 17:42 Sat	63	23	86	65.3

VESSEL B
DESCRIPTION: 200 -3000 TEUs (shipsgear)

DATE	VESSEL ARRIVAL	BERTH ARRIVAL	VESSEL COMMENCE	VESSEL COMPLETES
Jan-14	05/01/14 04:00 Sun	05/01/14 16:30 Sun	05/01/14 19:35 Sun	06/01/14 21:00 Mon
Jan-14	10/01/14 01:30 Fri	10/01/14 07:42 Fri	10/01/14 09:15 Fri	12/01/14 12:50 Sun
Jan-14	10/01/14 15:30 Fri	10/01/14 16:36 Fri	10/01/14 18:30 Fri	11/01/14 11:00 Sat
Jan-14	16/01/14 17:00 Thu	19/01/14 00:48 Sun	19/01/14 02:00 Sun	22/01/14 17:00 Wed
Feb-14	10/02/14 06:00 Mon	10/02/14 14:42 Mon	10/02/14 16:45 Mon	12/02/14 21:00 Wed
Feb-14	18/02/14 00:01 Tue	19/02/14 11:54 Wed	19/02/14 15:30 Wed	22/02/14 04:30 Sat
Feb-14	24/02/14 14:30 Mon	25/02/14 01:12 Tue	25/02/14 03:00 Tue	26/02/14 19:00 Wed
Feb-14	26/02/14 07:00 Wed	02/03/14 22:48 Sun	03/03/14 01:00 Mon	04/03/14 10:40 Tue
Mar-14	03/03/14 20:35 Mon	06/03/14 08:30 Thu	06/03/14 10:00 Thu	07/03/14 13:20 Fri
Mar-14	07/03/14 14:30 Fri	07/03/14 16:18 Fri	07/03/14 18:05 Fri	09/03/14 07:00 Sun
Mar-14	12/03/14 13:00 Wed	12/03/14 21:30 Wed	13/03/14 00:01 Thu	15/03/14 10:00 Sat
Mar-14	17/03/14 12:30 Mon	18/03/14 04:48 Tue	18/03/14 07:30 Tue	19/03/14 17:00 Wed
Apr-14	08/04/14 10:30 Tue	08/04/14 20:48 Tue	08/04/14 23:00 Tue	11/04/14 01:20 Fri
Apr-14	18/04/14 17:00 Fri	18/04/14 20:00 Fri	18/04/14 21:00 Fri	20/04/14 17:50 Sun
Apr-14	20/04/14 15:30 Sun	21/04/14 04:06 Mon	21/04/14 07:00 Mon	23/04/14 02:00 Wed
Apr-14	22/04/14 10:00 Tue	25/04/14 17:00 Fri	25/04/14 18:00 Fri	27/04/14 02:00 Sun
May-14	08/05/14 05:30 Thu	09/05/14 02:00 Fri	09/05/14 03:45 Fri	11/05/14 05:00 Sun
May-14	12/05/14 04:15 Mon	12/05/14 22:18 Mon	13/05/14 00:01 Tue	14/05/14 12:40 Wed
May-14	14/05/14 03:30 Wed	14/05/14 21:30 Wed	15/05/14 00:30 Thu	17/05/14 05:55 Sat
May-14	21/05/14 17:20 Wed	21/05/14 20:00 Wed	21/05/14 22:45 Wed	23/05/14 19:00 Fri
Jun-14	10/06/14 17:30 Tue	11/06/14 09:36 Wed	11/06/14 11:00 Wed	13/06/14 04:00 Fri
Jun-14	17/06/14 09:20 Tue	19/06/14 05:00 Thu	19/06/14 07:30 Thu	21/06/14 17:45 Sat
Jun-14	21/06/14 18:00 Sat	22/06/14 17:30 Sun	22/06/14 20:00 Sun	26/06/14 09:15 Thu
Jun-14	25/06/14 04:30 Wed	25/06/14 12:18 Wed	25/06/14 15:30 Wed	27/06/14 21:10 Fri
Jul-14	09/07/14 04:30 Wed	11/07/14 04:48 Fri	11/07/14 07:30 Fri	13/07/14 12:00 Sun
Aug-14	13/08/14 13:20 Wed	16/08/14 08:18 Sat	16/08/14 10:20 Sat	18/08/14 23:59 Mon
Aug-14	16/08/14 03:00 Sat	17/08/14 23:00 Sun	18/08/14 00:01 Mon	21/08/14 17:50 Thu
Aug-14	28/08/14 22:57 Thu	31/08/14 21:36 Sun	31/08/14 23:10 Sun	04/09/14 03:00 Thu

Sep-14	06/09/14 14:24 Sat	06/09/14 15:24 Sat	06/09/14 19:35 Sat	11/09/14 16:00 Thu
Sep-14	07/09/14 05:00 Sun	13/09/14 15:48 Sat	13/09/14 16:30 Sat	15/09/14 05:20 Mon
Sep-14	09/09/14 06:30 Tue	11/09/14 21:42 Thu	11/09/14 23:30 Thu	13/09/14 15:30 Sat
Sep-14	19/09/14 13:42 Fri	20/09/14 20:48 Sat	20/09/14 23:00 Sat	25/09/14 19:50 Thu
Oct-14	07/10/14 06:00 Tue	10/10/14 12:30 Fri	10/10/14 15:10 Fri	14/10/14 02:00 Tue
Oct-14	13/10/14 01:25 Mon	17/10/14 22:42 Fri	18/10/14 00:01 Sat	19/10/14 21:00 Sun
Oct-14	22/10/14 06:45 Wed	22/10/14 09:42 Wed	22/10/14 11:00 Wed	26/10/14 09:30 Sun
Oct-14	27/10/14 10:15 Mon	01/11/14 20:48 Sat	01/11/14 21:50 Sat	03/11/14 11:10 Mon
Nov-14	05/11/14 07:00 Wed	06/11/14 16:42 Thu	06/11/14 18:30 Thu	09/11/14 00:30 Sun
Nov-14	14/11/14 07:00 Fri	14/11/14 20:18 Fri	14/11/14 23:00 Fri	17/11/14 02:30 Mon
Nov-14	27/11/14 01:30 Thu	27/11/14 04:36 Thu	27/11/14 08:00 Thu	29/11/14 22:30 Sat
Nov-14	28/11/14 18:25 Fri	29/11/14 14:30 Sat	29/11/14 15:40 Sat	01/12/14 19:00 Mon
Dec-14	12/12/14 15:12 Fri	14/12/14 20:12 Sun	14/12/14 22:00 Sun	20/12/14 09:00 Sat
Dec-14	18/12/14 04:00 Thu	20/12/14 00:12 Sat	26/12/14 09:00 Fri	03/01/15 10:00 Sat
Dec-14	25/12/14 19:25 Thu	25/12/14 20:36 Thu	28/12/14 00:35 Sun	29/12/14 01:30 Mon
Dec-14	27/12/14 07:30 Sat	27/12/14 21:48 Sat	03/01/15 18:30 Sat	08/01/15 13:50 Thu
Jan-15	12/01/15 08:45 Mon	03/01/15 15:36 Sat	14/01/15 15:30 Wed	18/01/15 01:40 Sun
Jan-15	22/01/15 20:30 Thu	14/01/15 14:00 Wed	27/01/15 13:10 Tue	30/01/15 20:30 Fri

VESSEL SAILS	VESSEL TURAROUND TIME (hrs)	ANCHOR (hrs)	TOTAL TURNAROUND TIME (hrs)	SWH
06/01/14 22:54 Mon	25	17	42	55.5
12/01/14 13:42 Sun	52	9	61	47
11/01/14 13:06 Sat	17	5	22	65.8
22/01/14 18:42 Wed	87	59	146	28.6
12/02/14 23:00 Wed	52	13	65	52.7
22/02/14 07:18 Sat	61	42	103	46.9
26/02/14 21:06 Wed	40	15	55	70
04/03/14 12:42 Tue	34	116	150	50.6
07/03/14 15:12 Fri	27	63	100	61.5
09/03/14 13:06 Sun	37	10	47	81.9
15/03/14 14:18 Sat	58	15	73	40.1
19/03/14 19:06 Wed	34	21	55	70.8
11/04/14 02:24 Fri	50	14	64	51.1
20/04/14 19:48 Sun	45	6	51	65.5
23/04/14 03:18 Wed	43	17	60	57.7
27/04/14 03:12 Sun	32	81	103	44.9
11/05/14 06:48 Sun	49	24	73	47.1
14/05/14 14:06 Wed	37	21	58	58.4
17/05/14 07:48 Sat	53	23	76	57.3
23/05/14 19:54 Fri	44	6	50	59.7
13/06/14 07:24 Fri	41	21	62	60.1
21/06/14 19:06 Sat	58	48	106	32.4
26/06/14 10:54 Thu	85	28	103	29.6
27/06/14 23:18 Fri	54	13	67	57.8
13/07/14 12:42 Sun	53	52	105	57.8
19/08/14 01:06 Tue	47	25	72	60.1
21/08/14 19:00 Thu	62	70	132	14.8
04/09/14 04:30 Thu	90	46	136	32.5

11/09/14 16:42 Thu	0	0	0	21.3
15/09/14 12:54 Mon	0	0	0	26.6
13/09/14 19:18 Sat	0	0	0	63.7
25/09/14 22:30 Thu	0	0	0	29.3
14/10/14 04:24 Tue	83	84	167	61
19/10/14 23:36 Sun	45	121	166	51.3
26/10/14 10:06 Sun	95	5	100	25.2
03/11/14 15:30 Mon	37	136	173	51.8
09/11/14 01:18 Sun	54	36	90	36.4
17/11/14 08:12 Mon	51	22	73	59.2
30/11/14 00:18 Sun	62	8	70	42.9
01/12/14 20:12 Mon	51	22	63	80.8
20/12/14 14:12 Sat	131	60	191	17.6
03/01/15 12:00 Sat	68	49	117	62.7
29/12/14 03:54 Mon	193	16	209	18.8
08/01/15 16:36 Thu	25	19	44	46.8
18/01/15 03:48 Sun	115	37	152	35.6
30/01/15 23:18 Fri	82	57	139	22.3

DESCRIPTION: 4500 - 5000 TEUs (gearless)

DATE	VESSEL ARRIVAL	BERTH ARRIVAL	VESSEL COMMENCE
Mar-14	25/03/2014 21:05 Tue	26/03/2014 09:06 Wed	26/03/2014 12:32 Wed
Mar-14	28/03/2014 18:55 Fri	28/03/2014 20:36 Fri	28/03/2014 23:18 Fri
Mar-14	29/03/2014 03:14 Sat	29/03/2014 05:12 Sat	29/03/2014 09:11 Sat
Apr-14	04/04/2014 10:25 Fri	04/04/2014 13:06 Fri	04/04/2014 15:30 Fri
Apr-14	06/04/14 03:10 Sun	**06/04/2014 05:06 Sun**	06/04/2014 07:56 Sun
Apr-14	12/04/14 06:55 Sat	**12/04/2014 09:00 Sat**	12/04/2014 10:59 Sat
Apr-14	26/04/14 17:02 Sat	**27/04/2014 04:18 Sun**	27/04/2014 08:39 Sun
May-14	02/05/2014 10:45 Fri	02/05/2014 13:24 Fri	02/05/2014 17:38 Fri
May-14	04/05/2014 22:37 Sun	06/05/2014 07:12 Tue	06/05/2014 08:23 Tue
May-14	12/05/2014 07:39 Mon	13/05/2014 10:42 Tue	13/05/2014 12:01 Tue
May-14	18/05/2014 13:16 Sun	22/05/2014 04:30 Thu	22/05/2014 07:00 Thu
Jun-14	01/06/2014 08:50 Sun	01/06/2014 22:48 Sun	02/06/2014 22:10 Mon
Jun-14	08/06/2014 04:40 Sun	08/06/2014 09:19 Sun	08/06/2014 12:15 Sun
Jun-14	28/06/2014 15:18 Sat	28/06/2014 17:30 Sat	28/06/2014 20:20 Sat
Jul-14	01/07/2014 07:35 Tue	01/07/2014 15:36 Tue	01/07/2014 18:21 Tue
Jul-14	06/07/2014 16:29 Sun	07/07/2014 07:48 Mon	07/07/2014 09:43 Mon
Jul-14	23/07/2014 11:05 Wed	23/07/2014 13:36 Wed	23/07/2014 16:20 Wed
Jul-14	23/07/2014 00:17 Wed	23/07/2014 02:12 Wed	23/07/2014 04:27 Wed
Aug-14	03/08/2014 09:07 Sun	03/08/2014 11:18 Sun	03/08/2014 13:01 Sun
Aug-14	17/08/2014 21:36 Sun	17/08/2014 23:02 Sun	18/08/2014 01:34 Mon
Aug-14	24/08/2014 02:42 Sun	24/08/2014 05:00 Sun	24/08/2014 08:58 Sun
Aug-14	31/08/2014 17:47 Sun	31/08/2014 21:30 Sun	31/08/2014 23:37 Sun
Sep-14	14/09/2014 03:25 Sun	14/09/2014 05:20 Sun	14/09/2014 09:18 Sun
Sep-14	14/09/2014 18:48 Sun	15/09/2014 10:42 Mon	15/09/2014 12:12 Mon
Sep-14	22/09/2014 08:20 Mon	23/09/2014 03:12 Tue	23/09/2014 04:38 Tue
Sep-14	30/09/2014 06:55 Tue	02/10/2014 07:24 Thu	02/10/2014 09:14 Thu
Oct-14	07/10/2014 09:26 Tue	07/10/2014 11:18 Tue	07/10/2014 15:43 Tue
Oct-14	15/10/2014 02:52 Wed	15/10/2014 05:48 Wed	15/10/2014 07:55 Wed
Oct-14	20/10/2014 22:40 Mon	21/10/2014 05:12 Tue	21/10/2014 08:11 Tue

Oct-14	28/10/2014 02:42 Tue	28/10/2014 05:24 Tue	28/10/2014 07:40 Tue
Nov-14	04/11/2014 19:17 Tue	05/11/2014 17:18 Wed	05/11/2014 18:45 Wed
Nov-14	10/11/2014 07:00 Mon	12 Nov 2014 00:54	12/11/2014 02:55 Wed
Nov-14	16/11/2014 05:48 Sun	21/11/2014 01:00 Fri	21/11/2014 02:36 Fri
Nov-14	22/11/14 11:44 Sat	**22/11/2014 16:36 Sat**	22/11/2014 19:26 Sat
Dec-14	02/12/14 16:27 Tue	**02/12/2014 18:30 Tue**	02/12/2014 20:35 Tue
Dec-14	09/12/14 05:58 Tue	**09/12/2014 07:30 Tue**	09/12/2014 11:17 Tue
Dec-14	18/12/14 03:07 Thu	**18/12/2014 05:18 Thu**	18/12/2014 07:28 Thu
Dec-14	22/12/14 20:27 Mon	**23/12/2014 08:48 Tue**	23/12/2014 10:46 Tue
Jan-15	05/01/15 05:20 Mon	**05/01/2015 06:55 Mon**	05/01/2015 08:44 Mon
Jan-15	18/01/15 20:00 Sun	**18/01/2015 21:20 Sun**	18/01/2015 23:50 Sun
Jan-15	26/01/15 12:50 Mon	**27/01/2015 08:48 Tue**	27/01/2015 10:34 Tue
Jan-15	30/01/15 03:15 Fri	**30/01/2015 20:54 Fri**	31/01/2015 01:02 Sat
Feb-15	07/02/15 13:59 Sat	**07/02/2015 15:48 Sat**	08/02/2015 00:05 Sun
Feb-15	18/02/15 13:09 Wed	**19/02/2015 05:48 Thu**	19/02/2015 08:05 Thu
Feb-15	23/02/15 06:54 Mon	**23/02/2015 20:18 Mon**	24/02/2015 01:12 Tue
Mar-15	04/03/2015 06:32 Wed	04/03/2015 06:32 Wed	05/03/2015 02:17 Thu
Mar-15	09/03/2015 01:10 Mon	09/03/2015 01:10 Mon	11/03/2015 20:13 Wed
Mar-15	12/03/2015 14:50 Thu	17/03/2015 23:18 Tue	18/03/2015 01:14 Wed

VESSEL COMPLETES	VESSEL SAILS	TOTAL MOVES	TOTAL TURNAROUND TIME (hrs)	SWH
28/03/2014 01:00 Fri	28/03/2014 04:21 Fri	1 579	53.4	39.9
29/03/2014 20:45 Sat	29/03/2014 22:39 Sat	538	23.1	23.5
30/03/2014 00:20 Sun	30/03/2014 01:23 Sun	1183	22.1	70.6
05/04/2014 03:21 Sat	05/04/2014 05:00 Sat	1121	18.6	84.9
07/04/2014 01:24 Mon	**2014/04/07 03:02**	1093	23.3	53.1
13/04/2014 01:35 Sun	**2014/04/13 03:41**	630	20.8	37.8
28/04/2014 21:44 Mon	**2014/04/29 00:25**	1054	49.3	25.8
03/05/2014 16:15 Sat	03/05/2014 19:00 Sat	1091	32.3	41.9
08/05/2014 22:15 Thu	09/05/2014 00:02 Fri	1935	86.3	28.8
16/05/2014 06:31 Fri	16/05/2014 08:34 Fri	1498	96.9	20.1
25/05/2014 01:40 Sun	25/05/2014 02:59 Sun	2567	157.7	34.7
05/06/2014 16:18 Thu	05/06/2014 18:33 Thu	1722	85.7	11.9
10/06/2014 11:00 Tue	10/06/2014 12:33 Tue	1631	55.9	26.5
29/06/2014 14:15 Sun	29/06/2014 16:05 Sun	1001	24.8	48.8
03/07/2014 07:44 Thu	03/07/2014 09:23 Thu	1189	49.8	29.3
09/07/2014 13:50 Wed	09/07/2014 15:04 Wed	1004	62.6	17.5
25/07/2014 02:04 Fri	25/07/2014 05:12 Fri	1330	42.1	35
24/07/2014 07:00 Thu	24/07/2014 08:53 Thu	1095	32.6	33.4
04/08/2014 08:46 Mon	04/08/2014 10:46 Mon	1051	25.6	47.7
18/08/2014 20:39 Mon	18/08/2014 23:40 Mon	1096	26.1	52.7
25/08/2014 08:45 Mon	25/08/2014 11:52 Mon	1040	32.7	37.8
05/09/2014 09:09 Fri	05/09/2014 13:02 Fri	2822	74.3	20.3
15/09/2014 03:55 Mon	15/09/2014 07:06 Mon	1859	27.7	89.1
17/09/2014 07:00 Wed	17/09/2014 09:15 Wed	2244	62.4	49.7
24/09/2014 08:38 Wed	24/09/2014 10:54 Wed	1587	50.6	51.2
04/10/2014 07:58 Sat	04/10/2014 09:33 Sat	1550	88.6	31.8
08/10/2014 18:04 Wed	08/10/2014 20:04 Wed	1 480	28.5	54.3
18/10/2014 00:16 Sat	18/10/2014 03:30 Sat	2 663	66.4	29.1
22/10/2014 12:53 Wed	22/10/2014 15:22 Wed	928	40.7	10.6

30/10/2014 04:19 Thu	30/10/2014 07:06 Thu	2 034	45.5	40.6
08/11/2014 12:33 Sat	08/11/2014 14:35 Sat	2 488	91.3	23.7
14/11/2014 04:55 Fri	14/11/2014 07:10 Fri	1 360	94.4	8.6
22/11/2014 08:06 Sat	22/11/2014 10:32 Sat	1 403	148.7	45.2
26/11/2014 00:40 Wed	**2014/11/26 03:25**	2 006	39.1	25.1
04/12/2014 15:53 Thu	**2014/12/04 19:37**	2 325	49.9	48.1
10/12/2014 14:11 Wed	**2014/12/10 16:00**	1 559	33.6	55.8
20/12/2014 16:29 Sat	**20 Dec 2014 19:12**	2 618	64.1	43.9
24/12/2014 17:00 Wed	**2014/12/24 18:48**	1 027	39.1	31
07/01/2015 08:31 Wed	**2015/01/07 10:35**	2 192	52	34
20/01/2015 15:42 Tue	**2015/01/20 18:25**	2 101	41.9	49.1
29/01/2015 08:31 Thu	**2015/01/29 11:03**	2 001	64.7	33.6
01/02/2015 23:21 Sun	**2015/02/02 02:52**	899	50	14.3
09/02/2015 19:33 Mon	**2015/02/09 23:02**	2 771	46.8	60.1
21/02/2015 08:19 Sat	**2015/02/21 10:38**	2 173	65.4	32.5
24/02/2015 18:00 Tue	**2015/02/24 19:16**	697	31.5	36.8
07/03/2015 05:20 Sat	07/03/2015 07:32 Sat	1 729	73	5.4
13/03/2015 05:29 Fri	13/03/2015 07:30 Fri	1 466	100.8	33.2
19/03/2015 02:34 Thu	19/03/2015 04:37 Thu	1 326	156.7	45.9

VESSEL B
DESCRIPTION: 200 -3000 TEUs (shipsgear)

DATE	VESSEL ARRIVAL	BERTH ARRIVAL	VESSEL COMMENCE
Apr-14	09/04/2014 10:42 Wed	09/04/2014 13:12 Wed	09/04/2014 15:22 Wed
Apr-14	09/04/2014 15:50 Wed	09/04/2014 17:48 Wed	09/04/2014 19:20 Wed
Apr-14	17/04/2014 09:48 Thu	17/04/2014 11:30 Thu	17/04/2014 12:50 Thu
Apr-14	26/04/2014 16:30 Sat	28/04/2014 10:30 Mon	28/04/2014 14:10 Mon
May-14	05/05/2014 08:12 Mon	05/05/2014 10:00 Mon	05/05/2014 12:05 Mon
May-14	12/05/2014 13:45 Mon	13/05/2014 09:00 Tue	13/05/2014 11:29 Tue
May-14	20/05/2014 05:20 Tue	20/05/2014 15:42 Tue	20/05/2014 18:30 Tue
May-14	22/05/2014 20:25 Thu	06/06/2014 09:18 Fri	07/06/2014 20:44 Sat
Jun-14	17/06/2014 10:28 Tue	19/06/2014 23:54 Thu	20/06/2014 03:40 Fri
Jun-14	26/06/2014 00:27 Thu	26/06/2014 03:24 Thu	26/06/2014 07:32 Thu
Jun-14	27/06/2014 16:00 Fri	28/06/2014 16:00 Sat	03/07/2014 12:02 Thu
Jun-14	27/06/2014 18:10 Fri	04/07/2014 02:42 Fri	04/07/2014 04:36 Fri
Jul-14	04/07/2014 08:23 Fri	06/07/2014 02:48 Sun	06/07/2014 04:36 Sun
Jul-14	04/07/2014 23:06 Fri	09/07/2014 21:00 Wed	10/07/2014 00:28 Thu
Jul-14	07/07/2014 04:33 Mon	14/07/2014 13:12 Mon	14/07/2014 15:32 Mon
Jul-14	18/07/2014 08:47 Fri	18/07/2014 11:36 Fri	18/07/2014 13:44 Fri
Aug-14	02/08/2014 06:01 Sat	04/08/2014 11:48 Mon	04/08/2014 13:10 Mon
Aug-14	05/08/2014 17:00 Tue	07/08/2014 10:36 Thu	08/08/2014 23:20 Fri
Aug-14	20/08/2014 06:05 Wed	21/08/2014 20:48 Thu	24/08/2014 00:01 Sun
Aug-14	28/08/2014 04:53 Thu	28/08/2014 08:54 Thu	28/08/2014 11:12 Thu
Sep-14	08/09/2014 06:00 Mon	09/09/2014 12:00 Tue	09/09/2014 13:41 Tue
Sep-14	15/09/2014 13:29 Mon	16/09/2014 11:30 Tue	16/09/2014 13:10 Tue
Sep-14	24/09/2014 06:54 Wed	24/09/2014 09:00 Wed	24/09/2014 11:04 Wed
Sep-14	29/09/2014 03:25 Mon	29/09/2014 09:42 Mon	29/09/2014 14:10 Mon
Oct-14	08/10/2014 17:33 Wed	08/10/2014 21:36 Wed	08/10/2014 23:25 Wed
Oct-14	11/10/2014 05:04 Sat	11/10/2014 07:30 Sat	11/10/2014 09:34 Sat
Oct-14	23/10/2014 18:10 Thu	23/10/2014 20:00 Thu	23/10/2014 23:28 Thu
Oct-14	31/10/2014 02:41 Fri	31/10/2014 04:54 Fri	31/10/2014 08:29 Fri

Nov-14	01/11/2014 04:56 Sat	01/11/2014 08:06 Sat	01/11/2014 10:15 Sat
Nov-14	06/11/2014 11:01 Thu	06/11/2014 13:00 Thu	06/11/2014 18:14 Thu
Nov-14	13/11/2014 03:50 Thu	13/11/2014 11:06 Thu	13/11/2014 23:11 Thu
Nov-14	22/11/2014 11:20 Sat	22/11/2014 13:24 Sat	22/11/2014 15:27 Sat
Dec-14	03/12/14 05:00 Wed	**03/12/2014 07:12 Wed**	03/12/2014 10:23 Wed
Dec-14	05/12/14 10:53 Fri	**05/12/2014 12:54 Fri**	05/12/2014 15:49 Fri
Dec-14	12/12/2014 05:10 Fri	**12/12/2014 07:48 Fri**	12/12/2014 22:35 Fri
Dec-14	19/12/14 11:00 Fri	**19/12/2014 13:36 Fri**	19/12/2014 16:29 Fri
Jan-15	10/01/15 07:42 Sat	**10/01/2015 11:18 Sat**	10/01/2015 13:30 Sat
Jan-15	12/01/15 16:58 Mon	**13/01/2015 00:12 Tue**	13/01/2015 02:29 Tue
Jan-15	23/01/15 03:12 Fri	**23/01/2015 04:42 Fri**	23/01/2015 06:57 Fri
Jan-15	30/01/15 05:05 Fri	**30/01/2015 07:30 Fri**	30/01/2015 09:11 Fri
Feb-15	08/02/2015 02:58 Sun	08/02/2015 05:18 Sun	08/02/2015 08:11 Sun
Feb-15	15/02/15 23:00 Sun	16/02/2015 00:54 Mon	16/02/2015 08:32 Mon
Feb-15	22/02/15 17:56 Sun	22/02/2015 20:12 Sun	23/02/2015 09:16 Mon
Mar-15	01/03/2015 05:15 Sun	03/03/2015 17:36 Tue	03/03/2015 20:22 Tue
Mar-15	15/03/2015 03:21 Sun	17/03/2015 05:35 Tue	17/03/2015 08:15 Tue
Mar-15	19/03/2015 11:10 Thu	19/03/2015 12:54 Thu	19/03/2015 18:06 Thu

VESSEL COMPLETES	VESSEL SAILS	TOTAL MOVES	TOTAL(PORT)TURNAROUND TIME (hrs)	SWH
10/04/2014 00:35 Thu	10/04/2014 05:04 Thu	452	18.4	45.1
11/04/2014 22:49 Fri	12/04/2014 00:02 Sat	1 295	56.2	16.5
18/04/2014 05:17 Fri	18/04/2014 08:25 Fri	22.6	69	34
01/05/2014 06:39 Thu	01/05/2014 08:10 Thu	1754	106	20.1
08/05/2014 16:38 Thu	08/05/2014 18:14 Thu	2 024	62.6	24.3
15/05/2014 10:52 Thu	15/05/2014 13:06 Thu	2 294	71.3	46.1
23/05/2014 13:35 Fri	23/05/2014 15:42 Fri	2 117	82.4	28.4
08/06/2014 12:54 Sun	08/06/2014 15:28 Sun	571	40.3	29.1
21/06/2014 14:38 Sat	21/06/2014 16:07 Sat	1 763	101.6	46.8
26/06/2014 18:38 Thu	26/06/2014 17:33 Thu	436	17.1	36
03/07/2014 23:00 Thu	04/07/2014 01:42 Fri	232	153.7	20.4
04/07/2014 20:33 Fri	04/07/2014 23:06 Fri	779	172.9	43.1
07/07/2014 03:26 Mon	07/07/2014 04:33 Mon	734	68.2	27.3
10/07/2014 17:48 Thu	10/07/2014 19:42 Thu	570	139.3	28.2
16/07/2014 02:28 Wed	16/07/2014 03:45 Wed	581	201.9	13.9
20/07/2014 10:21 Sun	20/07/2014 12:02 Sun	1 075	51.2	6.2
05/08/2014 15:37 Tue	05/08/2014 17:12 Tue	760	128	26.2
10/08/2014 03:01 Sun	10/08/2014 04:39 Sun	1 704	57.9	56.7
25/08/2014 13:00 Mon	25/08/2014 15:10 Mon	2 126	47	52.9
30/08/2014 13:28 Sat	30/08/2014 15:23 Sat	1 620	30.6	20.8
10/09/2014 15:40 Wed	10/09/2014 18:00 Wed	688	60	26.5
18/09/2014 01:04 Thu	18/09/2014 03:17 Thu	1 260	57.1	31.6
26/09/2014 02:00 Fri	26/09/2014 03:30 Fri	1 689	44.6	37.1
02/10/2014 00:20 Thu	02/10/2014 02:11 Thu	1 079	50.1	12.8
10/10/2014 04:32 Fri	10/10/2014 07:11 Fri	1 217	36.7	28.9
13/10/2014 07:41 Mon	13/10/2014 10:12 Mon	2 163	43	53.1
24/10/2014 20:04 Fri	24/10/2014 22:59 Fri	882	25.9	39.1
01/11/2014 05:29 Sat	01/11/2014 07:00 Sat	1 183	26.9	50.8

02/11/2014 16:44 Sun	02/11/2014 18:54 Sun	1 311	36.8	28.3
08/11/2014 10:37 Sat	08/11/2014 12:30 Sat	1 132	48	15.1
14/11/2014 17:41 Fri	14/11/2014 19:48 Fri	1 160	40	61.5
23/11/2014 02:03 Sun	23/11/2014 07:08 Sun	496	19.8	44.7
04/12/2014 10:37 Thu	04/12/2014 12:39 Thu	857	28.6	26.9
06/12/2014 04:38 Sat	06/12/2014 08:52 Sat	804	22	59.3
14/12/2014 05:41 Sun	**2014/12/15 15:28**	1 852	82.3	57.1
20/12/2014 14:28 Sat	20/12/2014 15:57 Sat	914	28.9	36.6
11/01/2015 04:59 Sun	11/01/2015 05:42 Sun	795	22.4	45
13/01/2015 21:09 Tue	13/01/2015 22:54 Tue	1 010	29.6	48.3
24/01/2015 13:29 Sat	24/01/2015 15:00 Sat	952	36	28.1
31/01/2015 09:35 Sat	31/01/2015 11:12 Sat	713	28.4	18.3
08/02/2015 19:48 Sun	08/02/2015 21:48 Sun	743	19	58.6
17/02/2015 06:42 Tue	17/02/2015 08:30 Tue	1 366	33.2	57.3
24/02/2015 17:18 Tue	24/02/2015 18:24 Tue	861	45.9	19.4
04/03/2015 19:03 Wed	04/03/2015 21:40 Wed	1 014	84.9	40.2
18/03/2015 17:28 Wed	18/03/2015 19:08 Wed	1 112	82.6	29.9
20/03/2015 15:47 Fri	20/03/2015 17:48 Fri	1 193	30.7	49.2

VESSEL A			
DESCRIPTION: 4500 - 5000 TEUs (gearless)			
DATE	VESSEL ARRIVAL	BERTH ARRIVAL	VESSEL COMMENCE
Jan-14	02/01/14 18:00 Thu	03/01/2014 05:15 Fri	03/01/2014 07:30 Fri
Jan-14	08/01/14 06:00 Wed	08/01/2014 17:00 Wed	08/01/2014 18:20 Wed
Jan-14	10/01/14 13:03 Fri	10/01/2014 14:30 Fri	10/01/2014 17:00 Fri
Jan-14	12/01/14 18:00 Sun	13/01/2014 18:30 Mon	14/01/2014 01:00 Tue
Feb-14	05/02/14 12:00 Wed	05/02/2014 18:15 Wed	06/02/2014 03:30 Thu
Feb-14	06/02/14 05:30 Thu	06/02/2014 17:00 Thu	06/02/2014 19:00 Thu
Feb-14	11/02/14 22:00 Tue	12/02/2014 01:30 Wed	12/02/2014 02:35 Wed
Feb-14	14/02/14 05:00 Fri	14/02/2014 07:00 Fri	14/02/2014 12:45 Fri
Mar-14	05/03/14 22:30 Wed	06/03/2014 13:00 Thu	06/03/2014 15:40 Thu
Mar-14	07/03/14 12:45 Fri	08/03/2014 04:00 Sat	08/03/2014 06:10 Sat
Mar-14	10/03/14 10:00 Mon	12/03/2014 11:25 Wed	12/03/2014 12:10 Wed
Mar-14	13/03/14 00:10 Thu	13/03/2014 00:35 Thu	13/03/2014 04:00 Thu
Apr-14	08/04/14 04:00 Tue	08/04/2014 05:30 Tue	08/04/2014 07:50 Tue
Apr-14	09/04/14 05:00 Wed	09/04/2014 07:00 Wed	09/04/2014 08:40 Wed
Apr-14	14/04/14 16:20 Mon	14/04/2014 18:00 Mon	15/04/2014 07:50 Tue
Apr-14	16/04/14 13:40 Wed	16/04/2014 14:45 Wed	16/04/2014 16:00 Wed
May-14	08/05/14 05:15 Thu	08/05/2014 06:00 Thu	08/05/2014 10:00 Thu
May-14	14/05/14 05:37 Wed	14/05/2014 07:00 Wed	14/05/2014 10:00 Wed
May-14	15/05/14 06:35 Thu	15/05/2014 07:40 Thu	15/05/2014 08:30 Thu
May-14	20/05/14 12:00 Tue	20/05/2014 13:15 Tue	20/05/2014 15:50 Tue
Jun-14	04/06/14 14:00 Wed	05/06/2014 12:30 Thu	05/06/2014 15:40 Thu
Jun-14	05/06/14 12:00 Thu	06/06/2014 18:45 Fri	06/06/2014 20:00 Fri
Jun-14	10/06/14 18:15 Tue	10/06/2014 21:30 Tue	10/06/2014 23:00 Tue
Jun-14	12/06/14 05:00 Thu	12/06/2014 07:00 Thu	12/06/2014 09:15 Thu
Jul-14	02/07/14 05:00 Wed	02/07/2014 12:00 Wed	02/07/2014 13:00 Wed
Jul-14	04/07/14 06:00 Fri	04/07/2014 11:10 Fri	04/07/2014 17:00 Fri
Jul-14	09/07/14 17:05 Wed	09/07/2014 18:00 Wed	09/07/2014 20:00 Wed
Jul-14	10/07/14 17:00 Thu	10/07/2014 17:50 Thu	10/07/2014 17:00 Thu
Aug-14	02/08/14 14:00 Sat	03/08/2014 14:35 Sun	03/08/2014 15:30 Sun
Aug-14	07/08/14 08:28 Thu	07/08/2014 09:30 Thu	07/08/2014 11:05 Thu
Aug-14	08/08/14 04:00 Fri	08/08/2014 18:00 Fri	08/08/2014 20:00 Fri
Aug-14	13/08/14 10:00 Wed	13/08/2014 14:00 Wed	13/08/2014 15:00 Wed
Sep-14	04/09/14 06:00 Thu	04/09/2014 10:50 Thu	04/09/2014 11:00 Thu
Sep-14	04/09/14 15:55 Thu	04/09/2014 18:15 Thu	04/09/2014 19:00 Thu
Sep-14	11/09/14 23:00 Thu	12/09/2014 00:30 Fri	12/09/2014 01:30 Fri

Sep-14	13/09/14 14:00 Sat	13/09/2014 17:00 Sat	13/09/2014 19:15 Sat
Oct-14	01/10/14 05:10 Wed	01/10/2014 05:35 Wed	01/10/2014 08:00 Wed
Oct-14	03/10/14 07:55 Fri	04/10/2014 22:40 Sat	05/10/2014 00:01 Sun
Oct-14	07/10/14 14:00 Tue	07/10/2014 15:45 Tue	07/10/2014 16:30 Tue
Oct-14	08/10/14 05:00 Wed	08/10/2014 16:00 Wed	08/10/2014 17:20 Wed
Nov-14	03/11/14 15:00 Mon	03/11/2014 15:50 Mon	03/11/2014 19:00 Mon
Nov-14	05/11/14 06:00 Wed	05/11/2014 06:45 Wed	05/11/2014 07:45 Wed
Nov-14	10/11/14 05:00 Mon	10/11/2014 13:30 Mon	10/11/2014 15:00 Mon
Nov-14	12/11/14 05:15 Wed	12/11/2014 08:00 Wed	12/11/2014 09:30 Wed
Dec-14	02/12/14 05:00 Tue	03/12/2014 14:30 Wed	03/12/2014 16:00 Wed
Dec-14	03/12/14 14:00 Wed	05/12/2014 06:35 Fri	05/12/2014 08:45 Fri
Dec-14	08/12/14 21:55 Mon	09/12/2014 03:00 Tue	09/12/2014 04:10 Tue
Dec-14	10/12/14 11:30 Wed	10/12/2014 11:45 Wed	11/12/2014 00:45 Thu
Jan-15	05/01/15 05:00 Mon	07/01/2015 16:15 Wed	07/01/2015 17:30 Wed
Jan-15	10/01/15 02:00 Sat	10/01/2015 03:00 Sat	10/01/2015 08:15 Sat
Jan-15	14/01/15 06:00 Wed	14/01/2015 18:00 Wed	14/01/2015 21:35 Wed
Jan-15	15/01/15 12:00 Thu	15/01/2015 21:15 Thu	15/01/2015 23:00 Thu

VESSEL COMPLETES	**TOTAL MOVES**	**TOTAL(PORT)TURNAROUND TIME (days)**	**SWH**
04/01/2014 21:00 Sat	1 637	2	43.7
09/01/2014 10:45 Thu	1 153	1	70.2
11/01/2014 23:00 Sat	1 629	1	54.3
14/01/2014 21:20 Tue	991	2	48.7
07/02/2014 04:00 Fri	1 485	2	60.6
07/02/2014 19:00 Fri	1 565	2	65.2
12/02/2014 21:50 Wed	1 202	1	62.4
16/02/2014 13:25 Sun	1 370	2	40.9
07/03/2014 23:15 Fri	1 548	2	49
08/03/2014 19:30 Sat	729	1	54.7
14/03/2014 11:00 Fri	1 363	4	37
15/03/2014 07:30 Sat	2 012	2	44.2
09/04/2014 01:50 Wed	1 206	1	67
10/04/2014 03:00 Thu	1 637	1	89.3
16/04/2014 21:50 Wed	1 356	2	47.2
17/04/2014 12:50 Thu	1 484	1	71.2
09/05/2014 10:30 Fri	1 584	1	64.7
15/05/2014 11:30 Thu	1 740	1	68.2
16/05/2014 02:45 Fri	1 153	1	63.2
21/05/2014 03:30 Wed	1 025	1	87.9
07/06/2014 05:30 Sat	2 632	3	69.6
07/06/2014 22:00 Sat	1 265	2	48.7
12/06/2014 05:10 Thu	1 394	1	46.2
13/06/2014 17:50 Fri	2 154	2	69.3
04/07/2014 04:45 Fri	1 839	2	51.4
06/07/2014 01:20 Sun	1 228	2	43.3
11/07/2014 03:00 Fri	1 517	1	48.9
11/07/2014 19:30 Fri	1 076	1	40.6
04/08/2014 05:45 Mon	808	2	56.7
08/08/2014 20:50 Fri	1 785	2	52.9
09/08/2014 19:50 Sat	1 085	2	45.5
14/08/2014 10:30 Thu	1 011	1	53
05/09/2014 12:00 Fri	1 150	1	46
06/09/2014 02:50 Sat	1 579	1	49.6
13/09/2014 00:30 Sat	1 375	1	59.8

14/09/2014 14:15 Sun	1 074	1	56.5
02/10/2014 08:40 Thu	1 418	1	57.5
05/10/2014 14:40 Sun	1 012	2	69.1
08/10/2014 09:45 Wed	655	1	38
10/10/2014 03:00 Fri	1 550	2	46.7
04/11/2014 10:00 Tue	824	1	54.9
06/11/2014 14:00 Thu	1 300	1	49.5
11/11/2014 15:25 Tue	858	1	35.1
13/11/2014 15:25 Thu	1 342	1	44.9
05/12/2014 13:35 Fri	645	3	34.7
06/12/2014 14:45 Sat	926	3	52.9
11/12/2014 02:00 Thu	1 677	3	46.5
12/12/2014 06:00 Fri	2 082	1	71.2
08/01/2015 15:00 Thu	1 528	3	71.1
11/01/2015 22:15 Sun	1 389	2	51
15/01/2015 13:00 Thu	831	1	66.9
17/01/2015 04:00 Sat	1 345	2	50.2

VESSEL B			
DESCRIPTION: 200 -3000 TEUs (shipsgear)			
DATE	VESSEL ARRIVAL	BERTH ARRIVAL	VESSEL COMMENCE
Mar-14	30/03/14 14:00 Sun	01/04/2014 15:55 Tue	01/04/2014 18:00 Tue
Dec-14	12/12/14 04:25 Fri	12/12/2014 06:00 Fri	12/12/2014 07:00 Fri
Dec-14	19/12/14 05:00 Fri	19/12/2014 16:00 Fri	19/12/2014 17:15 Fri
Dec-14	29/12/14 08:35 Mon	02/01/2015 01:40 Fri	03/01/2015 00:01 Sat
Jan-15	03/01/15 06:00 Sat	04/01/2015 16:00 Sun	04/01/2015 17:00 Sun
Jan-15	11/01/15 05:15 Sun	12/01/2015 03:50 Mon	12/01/2015 07:00 Mon
Jan-15	18/01/15 17:35 Sun	18/01/2015 18:50 Sun	19/01/2015 09:00 Mon
Jan-15	25/01/15 19:30 Sun	25/01/2015 22:00 Sun	25/01/2015 23:55 Sun
Feb-15	07/02/15 05:25 Sat	07/02/2015 07:10 Sat	07/02/2015 09:00 Sat
Feb-15	09/02/15 10:00 Mon	09/02/2015 12:30 Mon	09/02/2015 14:45 Mon
Feb-15	24/02/15 11:40 Tue	27/02/15 05:10	27/02/15 07:00
Mar-15	08/03/15 06:37 Sun	10/03/15 09:30	10/03/15 10:30
Mar-15	13/03/15 03:47 Fri	14/03/15 16:10	14/03/15 17:10

VESSEL COMPLETES	**TOTAL MOVES**	**TOTAL(PORT)TURNAROUND TIME (days)**	**SWH**
02/04/2014 01:30 Wed	203	2	27.1
12/12/2014 13:15 Fri	482	0	77.1
20/12/2014 09:45 Sat	963	1	58.4
03/01/2015 14:30 Sat	402	5	34
05/01/2015 05:00 Mon	817	2	68.1
13/01/2015 01:00 Tue	924	2	51.3
20/01/2015 20:15 Tue	1050	2	52.5
26/01/2015 13:50 Mon	875	1	62.9
07/02/2015 22:30 Sat	1576	1	116.7
09/02/2015 20:50 Mon	568	0	93.4
28/02/15 12:40	1015	4	61.2
12/03/15 01:30	1461	4	55.1
15/03/15 10:00	716	2	53.6

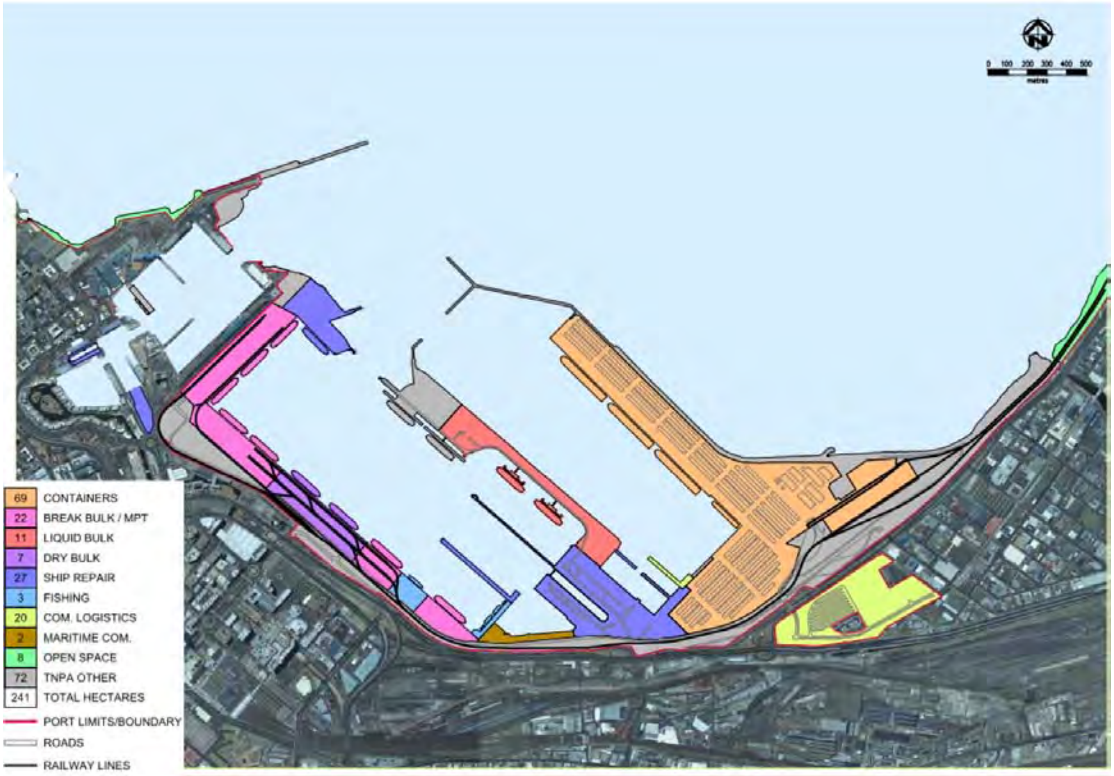
Exhibits

EXHIBIT 1

Durban Container Terminal Layout

Ngqura Container Terminal Layout

<u>Cape Town Container Terminal Layout</u>



Ethical Clearance

UNIVERSITY OF ™
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI

11 January 2016

Ms Innocentia Itumeleng Greta Motau (213572290)
School of Accounting, Economics & Finance
Westville Campus

Dear Ms Motau,

Protocol reference number: HSS/0032/016M
Project title: An assessment of Port Productivity at South African Container Ports Terminals

Full Approval – No Risk / Exempt Application

In response to your application received on 23 December 2015, 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

....

Dr Shenuka Singh (Chair)

/ms

Cc Supervisor: Professor Trevor Jones
Cc Academic Leader Research: Dr Harald Ngalawa
Cc School Administrator: Ms Nondumiso Mfungeni

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
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Website: www.ukzn.ac.za

1910 - 2010
100 YEARS OF ACADEMIC EXCELLENCE

Founding Campuses — Edgewood — Howard College — Medical School — Pietermaritzburg — Westville