Exploring the efficiency of the Navis Terminal Operating System at Transnet Durban Port, South Africa.

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DECLARATION

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ABSTRACT

Competition in harbours has meant that container terminal operators must constantly improve their efficiency to survive in this business. The rapid growth in cargo volumes and shipments from around the globe resulted in significant productivity and operational inefficiencies at terminals as harbours faced the challenge of meeting ever-growing demand. The main causes were increased competition, incompleteness of data, freight damage, rail or road bottlenecks, inadequate operational planning, and management. Therefore, seaport terminals needed to adopt TOS solutions such as Navis that would improve operational efficiency, throughput, and economic growth. However, a gap was identified in ensuring seamless and efficient terminal operations despite the introduction of these technological solutions. To find a solution to these inefficiencies that leave traces of economic, organizational, and reputational damage. A research model was developed through an integration of the AST, TTF and TOE model to explore the efficiency of the Navis TOS at Transnet Port of Durban, the largest port in South Africa. To capture a deep understanding for the efficiency of the terminal operations system in cargo handling at the Transnet Port of Durban and to draw appropriate conclusions for the study, a qualitative design approach is fitting. A population of 10 participants from Transnet Port of Durban employees was selected using a non-probability sampling. The selected cohort consist of one executive manager, two general managers, two terminal managers, two system engineers, two business analysts and one consultant from various department who are experts on the topics covered in this study. Interviews were used as a data collection tool. Data analysis was performed using NVivo computer software for data capturing and transforming data. Thematic analysis was utilized for primary data, while content analysis was utilized for the secondary data.

The Transnet Port of Durban should consider purchasing straddle equipment as a matter of urgency to increase the capacity for the current fleet and for the replacement of old fleet which is almost at the end of its useful life. It is imperative that an adequately resourced 24/7 workshop for servicing and repair be set up. The workshop must be resourced by employees with the required skills and have enough inventory to ensure that it runs efficiently. This will resolve the challenge of queues at the Transnet Port of Durban.

Keywords: Container Terminal; Efficiency; Navis; Terminal Operating System.

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AI – Artificial Intelligence

AST – Adaptive Structuration Theory

Covid-19 – Coronavirus disease of 2019

CTOC – Container Terminal Operations Contract

DPE – Department of Public Enterprises

EDI – Electronic Data Interchange

ERP – Enterprise Resource Planning

GDP – Gross Domestic Product

GDSS – Group Decision Support Systems

LAN – Local Area Network

ICT – Information and Communication Technology

IoT – Internet of Things

IS – Information Systems

IT – Information Technology

ITZ – Intermodal Transition Zone

OEM – Original Equipment Manufacturer

RFID – Radio-Frequency Identification

RMG – Rail Mounted Gantry cranes

RTG – Rubber Tyred Gantry cranes

SA – South Africa

SAP – System Applications Products

SC – Straddle Carriers

TOE – Technology-Organization-Environment

TOS – Terminal Operating System

TNPA – Transnet National Ports Authority

TPT – Transnet Port Terminals

TTF – Task-Technology Fit

WABA – Within and Between Analysis

CHAPTER ONE – INTRODUCTION AND BACKGROUND TO THE STUDY

1.1 INTRODUCTION

Container Terminals are integral part of the global trade network. All ports aspire to be a global trade network of choice to shipping lines. However, port efficiency influences cargo volumes that the shipping lines decides to load and discharge on behalf of their customers in a particular port. Port efficiency also drives economic activities in strategic port regions. As a result, ports must continuously innovate their operational processes to remain efficient and keep their respective regions "attractive" in the global logistics chain. It is for this reason container terminals rely on Information and Communication Technology (ICT) products to manage the flow and storage of different types of cargo in the port. The ICT products are mostly recognized as Terminal Operating System (TOS). Transnet has deployed Navis TOS to manage the flow and storage of cargo in all ports. However, it is concerning that the efficiency of South African ports, especially Transnet Port of Durban, are still considered suboptimal by global standards (Jungen et al., 2021).

Transnet Port of Durban used to welcome about 4500 vessels annually and about 83000 containers per month, but these numbers have reduced, making the port lose the edge against competing ports (Oguti, 2017). As of 2019, Transnet Port of Durban turnaround time averaged 299 minutes for over 2.8 million Twenty-Foot Equivalent Units (TEUs) handled in a period that ended 31 March 2021, which is below industry performance for a port of its size (Naidoo, 2021). Rapid growth and the urgent need for efficient, reliable, and successful port facilities requires research to establish ways to improve the TOS (Zehendner & Feillet, 2014).

The efficiency of the TOS has become an increasingly important subject of discussion as it serves as an enabler of operational tasks within the ports. It promotes equipment preparation, scheduling, and control (Kammoun, 2018). Ports play an important role as a link between the various modes of transport administration globally. Moreover, the efficiency of ports is integral to the termini as it forms part of national port authorities' strategy to remain competitive in a global network.

Nonetheless, container terminals are battling with ever-growing cargo volumes calling at the ports and increasing efficiency requirements. Heilig and Voß (2017) state that due to limited space, container terminals should look for solutions that increase the port's throughput capacity without increasing the amount of space they occupy. They need to also aim to improve the efficiency and productivity of vessels, so that they can accommodate vessels with greater call sizes in the same amount of time. Recently, more and more activities are being carried out on

TOS, which must be perfectly coordinated with the cargo handling strategy of the port operators. These include storage preparation, equipment grounding decisions, and dispatching to minimise operational risks and costs.

The economic downturn from 2007 to 2008, which caused a slump in economic activity that led to the worldwide financial crisis from 2008 to 2012, increased competition among ports around the world (Eaton et al., 2016). According to Verhoeven (2010), this has resulted in the need to incorporate measurement techniques and efficient cost control processes into port terminal operations to support project implementation and reinforce good management. These recessions and economic slowdowns have forced port terminals around the world to technologically improve their TOS efficiency to increase their market share. Some of the good management innovations are defining crane efficiency and vessel work performance because they are the key indicators for port terminal efficiency. This study seeks to explore the efficiency of terminal operations system to improve port operations and handling of cargo in general.

1.2 Background of the Study

In 2011, the Transnet Port of Durban was the biggest and busiest port in the Southern Hemisphere, handling 2.1 million Twenty-foot Equivalent Units (TEUs) per year, using Navis TOS. With about 65% of South Africa's seaborne cargo handled here, it is important for the Transnet Port of Durban to remain competitive on a global scale (Transnet Port Terminals, 2013b).

The Ports Regulator Benchmarking Report (2015) states that the average TEUs per hectare is 22, 344. However, Transnet Port of Durban appears to be the largest of all local ports in South Africa at 14,930 TEUs per hectare. In a global comparison, China's Shanghai has the highest value at 94,380 TEUs per hectare. That is six times more than the busiest and largest port in South Africa. In many cases, the container volumes handled in South African ports is smaller than in international comparator ports. When TEUs per hectare are measured, there is an indication that South African terminal space could be used more productively and efficiently. This deviation reflects that the potential in the local ports is not fully explored. The response to rising demand has been slow and limited on the supply side of the global logistics chain (Ports Regulator Benchmarking Report, 2015).

South African ports are exclusively government owned. KwaZulu-Natal has the two ports in Durban and Richards Bay. The Eastern Cape has three ports in East London, Port Elizabeth

and Ngqura. The Western Cape has two ports in Cape Town and Saldanha. The Transnet port network shown in Figure 1.1 displays how strategically placed is the Port of Durban, thus the study being undertaken in this port.

All these ports are controlled by Transnet and the Port of Durban is main port in South Africa serving as a multipurpose port, managing containers, dry and wet bulk as well as break bulk and automotive cargo.

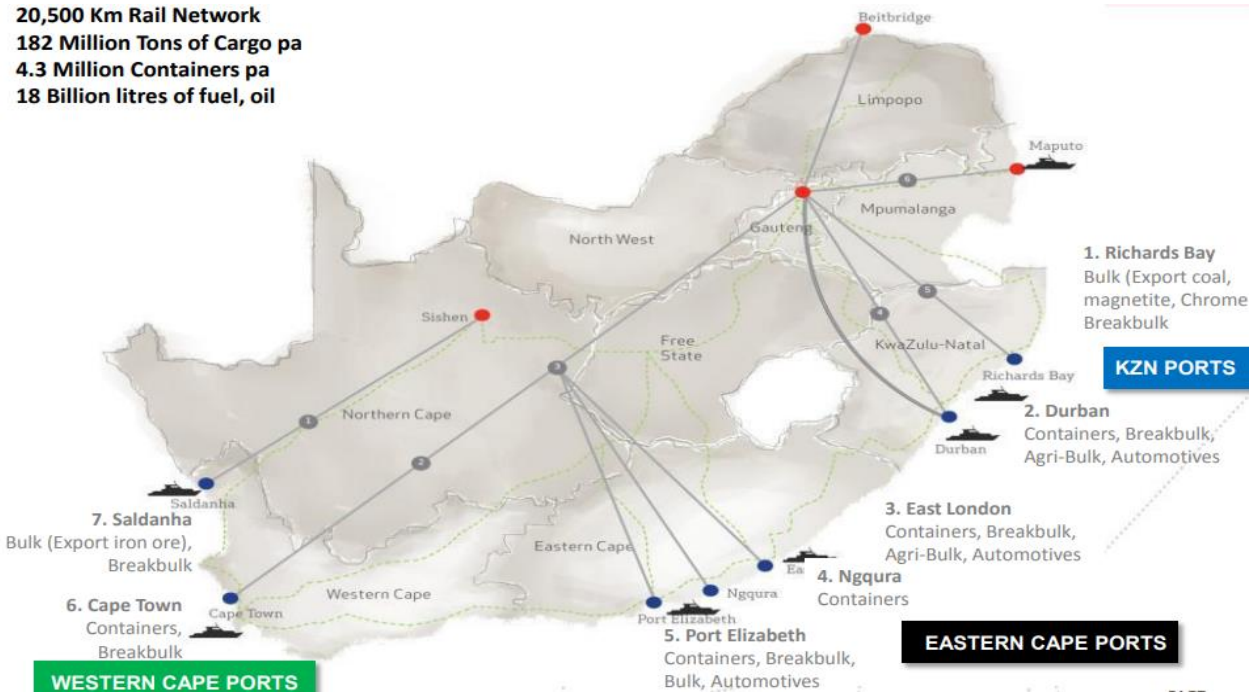

Figure 1. 1: A Case Study of Transnet Port Network
Source: Transnet Port Terminals (2013c, p. 3).

TNPA has two pilot helicopters, three survey boats, four dredgers, seven work boats, nine pilot boats and 26 tugs to enhance efficiency in port services and boost productivity. The Transnet Port of Durban is the heartbeat of the South African economy, and its efficiency is of high importance in the region. It is unfortunate that the port is associated with continual delays in their operations, and this resulted in growing reluctance for shipping lines to dock their vessels in Durban.

Consequently, the numbers have reduced and in the last 10 years as the status of the best performing port on the African continent was lost, since then the port is third on the African ports ranking. The geographic location of the port is so strategic and with so much potential, but the port does not take full advantage of that, and the economy is suffering. As a result, the Transnet Port of Durban adversely impact economic growth and is no longer perceived as a gateway to the region and Africa at large.

The increasing intermodality and globalization of container shipping, as well as the increasing rivalry in container handling between main ports, require continuous improvement in the output and performance of container terminals (Setiawan et al., 2018). According to Min et al. (2017), the Transnet Port of Durban contributes significantly to the economy of South Africa through important imports, exports of cargo that results into several jobs created within the city. To remain an attractive port, it must continuously make tremendous efforts to create value for stakeholders by ensuring efficient and effective terminal operations. However, due to the significant increase in container volumes over time, the port faces significant capacity constraints, berthing delays, and inefficiencies in general.

Task is a major source of structure in the Adaptive Structuration Theory (AST) that interacts with other sources, including technology and the internal system of the seaport, to influence operational procedures (DeSanctis & Poole 1994). The flow of effects for computer systems work groups task is a crucial input component as it works in conjunction with other input variables, including technology and group member traits, to create circumstances that lead to varying patterns of gang members interaction. When task and technology combine to produce optimal performance, the integration of AST with the other two theories that are task-oriented plays a vital role as a source of variety in this study.

The study integrated a Task-Technology Fit (TTF) model to direct an empirical analysis of the task and technology fit. In context to this study, task-technology should fit in such a way that it enhances gang members performance. A group of instruments for arranging, communicating, and processing data are intended to enable the achievement of seaport efficiency. The TTF model concept of technology describes the equipment gang members use to complete operational tasks using information systems' hardware, software, and data (Goodhue & Thompson, 1995).

An effective Technology-Organization-Environment (TOE) helps companies predict future patterns and prepare for and meet future needs. According to Schmitz et al. (2016), the TOE focus on three aspects, that is technology, organization, and environment. The technological dimension deals with the technologies that the company uses in carrying out its operations. While the scope of the organization is often considered because it includes the scope, goals, and priorities of the organization. The environmental aspect, on the other hand, is more concerned about the operational environment or atmosphere of the company. Improving cargo handling efficiency seems to be the only way to remain profitable for ports around the world, Transnet Port of Durban in particular (Carlo et al., 2014a).

The challenges that are faced by Transnet Port of Durban are illustrated Figure 1.2. These challenges range from inefficient utilization of equipment, resources and gate processes are intertwined with ever changing environmental conditions hindering efficiencies (Transnet Port Terminals, 2013b). As a result, the study explores how is the workload, equipment actual usage, and vessel turnaround time with the Navis TOS determines cargo throughput at the port. The study unpacks these challenges in Figure 1.2 to unlock efficiency bottlenecks at the Transnet Port of Durban.

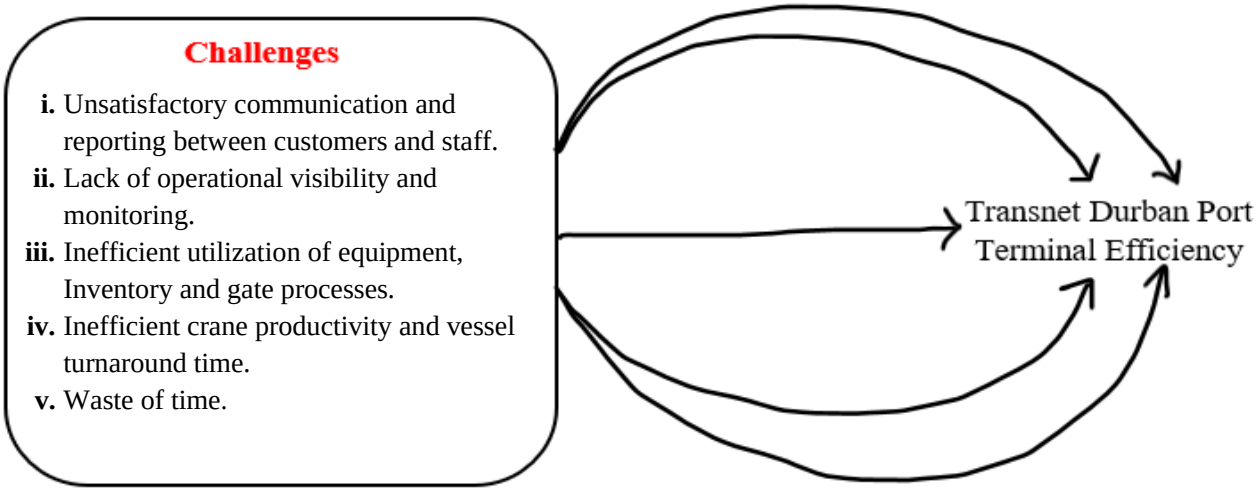

Figure 1. 2: Transnet Port of Durban Terminal Challenges
Source: Authors Own Design – OECD (2014, p. 45 – 46)

Transnet Port Terminals (TPT) embarked on a project to install the Navis Terminal Operating System (TOS) with the aim of achieving world-class terminal operations that will improve operations at South African Ports. Navis TOS has consolidated its position as the most advanced terminal operating system, being able to perform administration, monitoring, and management of terminal processes. Therefore, it was the obvious choice for TPT, as it is already used at more than 250 sites in 50 countries, and this is making it the industry leader. (Transnet Port Terminals, 2013a).

1.3 The Research Problem

The port users pinpointed lengthy waiting periods at an anchorage to access berths and berth time delays as the main operational challenges confronting Transnet Port of Durban. Kammoun (2018) postulates that factors such as port structural efficiency, storage strategies, knowledge sharing among stakeholders, and operating costs require strategic coordination and a balanced approach to optimize port productivity. In addition, information technology systems are sold as off-the-shelf products, and customising information technology systems to meet the needs and requirements of a particular port for optimal efficiency is usually fraught with challenges

(Gekara & Nguyen, 2020). At the time of purchase, it is almost impossible for these systems to be used by the customer as “out of box” and usually require some degree of customization.

Most recent research in this area has found that not all terminal operating system deployment projects yield optimal benefits (Setiawan et al., 2018). This contributes to the inefficiencies that leave traces of economic, organizational, and reputational depressions. Therefore, it is necessary to investigate the causes and try to reverse the disturbing pattern (Renken et al., 2018).

The main goal of information technology systems implementation projects is to match the functions of information technology systems to the needs and requirements of the organization (Kammoun, 2018). This study explores how effective is the TOS designed to manage, control delivery, storage, container processing and unloading operations at the Transnet Port of Durban to improve cargo handling. The study seeks to detect factors limiting expected efficiency to make possible improvement advances as per the tried and tested methods, along with harvesting synergies with ports producing consistent container terminals efficiency. The study highlights the importance of efficient TOS with respect to low and inconsistent efficiency over time. Therefore, the research is targeting to answer exploration of the Navis Terminal Operating System efficiency at the Transnet Port of Durban.

1.4 Research Questions

The study questions are as follows:

1.4.1 What is the impact of workload on operational efficiency of the Navis TOS at the Transnet Port of Durban Terminal?

1.4.2 What is the extent of Navis TOS utilization is optimizing operational efficiency at Transnet Port of Durban Terminal?

1.4.3 What is the impact of throughput on the performance of the Navis TOS in improving operational efficiency at Transnet Port of Durban Terminal?

1.4.4 What is the relationship between the actual utilization of the Navis TOS and operational efficiency at Transnet Port of Durban Terminal?

1.4.5 How useful are the available technologies in executing operational tasks to improve efficiency at Transnet Port of Durban?

1.5 Research Objectives

The objective of the study is to explore the efficiency of Navis TOS at Transnet Port of Durban, South Africa. The study aims:

1.5.1 To determine the impact of workload on operational efficiency of the Navis TOS at Transnet Port of Durban Terminal.

1.5.2 To determine utilization of the Navis TOS at Transnet Port of Durban Terminal in optimizing operational efficiency.

1.5.3 To determine the impact of throughput on the Navis TOS in improving operational efficiency at Transnet Port of Durban Terminal.

1.5.4 To establish the impact of actual use on operational efficiency of the Navis TOS in improving operational efficiency at Transnet Port of Durban Terminal.

1.5.5 To determine the usefulness of available technology in executing operational tasks to improve efficiency at Transnet Port of Durban

1.6 Rationale of the Study

Transnet Port Terminals is not maximising the full potential of the strategical positioned Port of Durban that manages more than 60% of containers in South Africa (Naidoo, 2021). Recently, the Transnet Port of Durban has slipped from being perceived as a leading port in Africa on the 2021 Global Container Port Performance Index, to position 364 ports worldwide. Transnet Port of Durban dropped to the bottom three in sub-Saharan Africa (World Bank, 2021). This lowest position ever seen by this glorious port established in 1824 as Port Natal then, was centred on perceptions of dropping performance.

Transnet Port of Durban enhanced capability will reposition the container terminal to meet the stakeholders' expectations and become attractive through its competitiveness. The need for greater operational efficiency, faster information exchange, and faster turnaround times for vessels are just some of the critical factors that highlight the port's central role within logistics systems and supply chains (Prokopowicz & Berg-Andreassen, 2016). Logistics chains span continents where production can occur in one region and demand in another. Cargo and shipments from all over the world have increased exponentially. Nevertheless, ports have not kept pace with rising economic growth. In fact, many ports are encountering difficulties. There are many bottlenecks related to the level of information and the physical condition of cargo, resulting in low productivity in the terminal. There are some obstacles to increasing the Transnet Port of Durban capacity through internal expansion and the recommended dig-out

port at an old Durban International Airport site (Havenga et al., 2017). This study is therefore stimulated by rapid growth and the urgent need to provide reliable and efficient services in container terminal port operations for Transnet (Bichou, 2021).

1.7 Significance of the Study

The TOS enables better utilization of assets, workforce, and equipment to plan workload, and obtain latest information. Through its ability to integrate information systems and knowledge management, the Transnet Port of Durban can guarantee a desirable efficiency level to the port stakeholders. The perceived container terminal efficiency means low handling costs, inexpensive storage, and quick turnaround times for the customers is propelled by system reliability.

Although Prokopowicz and Berg-Andreassen (2016) has provided insight into the operation or design of a port terminal operating system, The researcher points out that the Transnet Port of Durban has not yet fully adopted this paradigm into a single, easy-to-use tool for the efficient planning and decision-making phase of management for a fully customized and optimized information system technology. As the study focuses on the efficiency of the "Terminal Operating System" in cargo handling, this can improve the Port of Durban Terminal ability to reposition the port to meet the customers' expectations. It can further boost its competitiveness, make it attractive again and drive the economy of South Africa as well as other Southern African Development Community nations (Patil & Kadam, 2021).

1.8 Dissertation Structure

The study is presented in five chapters, as described below:

1.8.1 Chapter One – Introduction and Background to the study

Chapter one introduces the study, focusing on the background, problem statement, research questions, aims and objectives of the study. In addition, the significance and organization of the study are presented, and winding-up a chapter at the end.

1.8.2 Chapter Two – Literature Review

Chapter two explores the literature on terminal operating system concepts aligned with the operational efficiency and the theoretical framework used for the study. The purpose of this chapter is to analyse what other researchers have found and established about the operational efficiency with a special focus on the "terminal operating system" in cargo handling. Finally,

it justifies the choice of combining AST, TOE and TTF theories as the authors model for this study.

1.8.3 Chapter Three – Research Methodology

Chapter three develops the research design and methodology, focusing on the design and techniques used and explains the rationale behind their selection. The exploratory research design was adopted, using a purposive and non-probability sampling to obtain a primary data that originate from addressing the research objectives and the problem being explored. The data was obtained through in-depth, virtual interviews on Microsoft Teams platform.

1.8.4 Chapter Four – Data Analysis, Results, and Interpretation

In chapter four, the analysis of data and discussion of the results are presented based on the purpose of the study. The results are then presented following a thematic Within and Between Analysis (WABA), linking the literature to the findings.

1.8.5 Chapter five – Findings and Discussions

Chapter five delivers the conclusions and recommendations of the study. This chapter details how the study objectives were fulfilled to answer research questions. Finally, the chapter makes recommendations based on the results presented in the previous chapter and then draws conclusions on the study.

1.9 Chapter Summary

Transnet made substantial investment in the terminal operating system infrastructure. This was with the view that Port of Durban would become world-class and improve terminal operations as it is the busiest port in South Africa. However, the Transnet Port of Durban is becoming less attractive to the shipping lines due to performance related issues. This chapter highlights the challenges of terminal efficiency at the Transnet Port of Durban. The study seeks to explore the efficiency of the Navis TOS through research questions to address challenges that cause performance issues at the Transnet Port of Durban to make it a competitive port again.

The researcher introduced the study, outlined the background, research problem statement, questions, as well as research aim and objectives, the significance of this study, and finally the format of the research chapters. The next chapter of the study deals with a literature of what other researchers have found and established about the efficiency of terminal operating system in different ports.

CHAPTER TWO – LITERATURE REVIEW

2.1 INTRODUCTION

This section seeks to provide a study-related literature to review port efficiency using TOS. The rationale of investigating the efficiency of TOS at Transnet Port of Durban is articulated in chapter one. The contribution from different authors will provide a body of knowledge on which to base essential claims and arguments for the research model and give a thorough understanding of the ICT products in relation to port efficiency. The port model in South Africa, overview of the ports, terminal operating system, efficiency of Transnet Port of Durban, factors contributing to the efficiency, capacity of the port and a research model for the study is discussed in detailed.

With the pace at which digitalization is increasingly permeating the maritime and transportation industries, attention is now being paid to making sure that the various means of transportation are interfacing with TOS and much more connected to address the harmonization issues that port calls present (Lind et al., 2021). As there are many parties involved in the global logistics chain, necessary steps need to be taken to improve the coordination and synchronization of cargo in the rapidly evolving digital landscape by exchanging the information on which they are mutually dependent.

A growing number of maritime and port authorities are working through TOS to facilitate digital collaboration among sea transport participants, particularly about port operations (de la Peña Zarzuelo et al., 2020). The cargo shipping industry is faced with a changing dynamic of technology, procedures, and organizational structures, and it is imperative for container terminal administrators to meet these challenges (Dooms et al., 2013). Despite the fact that international container transportation is crucial to the growth of the world economy, not much research have been conducted on an efficiency of TOS.

2.2 Port Model in South Africa

Up to the year 2002 Portnet had a full control over South African ports which were eventually divided into a landlord division, Transnet National Port Authority (TNPA) and the operator, Transnet Port Terminals (TPT) as an outcome of the National Commercial Port Policy of 2002 white paper adoption. According to Kaliszewski et al. (2020), the ports of South Africa are therefore some of the few cases in the world where all three port roles are all under state control, namely regulator, landowner, and operator. South African ports serve as economic hubs, directing commerce between South Africa and other countries. Because of South Africa's

geographic position, most of the trade is conducted by sea through the ports in Figure 1.1 and in addition, Mossel Bay port.

The South African ports are controlled by Transnet SOC Limited. The landlord is responsible for ensuring that the national port network is operated efficiently and safely. As guided by National Ports Act (Act No. 12 of 2005) their business offerings entail the establishment of port infrastructure and marine services (Prokopowicz & Berg-Andreassen, 2016). This Act identifies the provision, maintenance, and expansion of port facilities, as well as the provision of a road or rail access plan for the ports, as part of the primary responsibilities. Durban and Richards Bay are the only ports with clear and significant private participation. TPT oversees all major terminal operations, while TNPA oversees the overall management of the ports (Kaliszewski et al., 2020).

2.3 An Overview of the Ports

The goal of the port reform in Africa is to increase trade competitiveness and cut government spending. This sector reform is one part of a larger transport sector reform program. Increasing port efficiency, lowering port service costs, boosting hinterland connectivity, creating superior services in terms of quality, and minimizing idle time are all ways to improve competitiveness. As the size and function of the public sector are reduced and some expenditures are moved to the private sector, which eventually serves as a source of income through taxes and concession agreements, government funding on state owned companies is reduced (World Bank, 2018).

At present, the ports sector is in dire need of money, considering diminishing governmental subsidies and the requirement for new investments. Through the involvement of the private sector, Africa as a continent started a comprehensive reform of the port industry (Arvis et al., 2018). Since 2000, the principal international operators have been granted concessions at several of the continent's large container terminals. A notable result was the simplicity with which the government decentralized its control over the port industry, resulting in increased port productivity (World Bank, 2018).

2.3.1 Port Management Models

Carlo et al. (2014a) establish that there are four main models for the management of ports, distinguished by the degree of commitment expected from both the public and private sectors. These are the "public service", the "tool", the "landlord", and the "fully privatized" operating port models.

2.3.1.1 Public Service Port

It is supported with government plans to implement port system infrastructure to facilitate trade with global markets. Government invests in setting up ports and pass regulations to ensure they are sustainable enterprises. The downside of this model is limited competition and innovative policies to manage the ports, which results in an average port operations and management (Khiem, 2017). The government also has full control of budget and as a result some of the opportunities are not funded if presumed not part of the government agenda. The Transnet Ports (Durban) is managed through this model, shown in Table 2.1, by the Department of Public Enterprise (DPE) using social compact.

2.3.1.2 Tool Port

In this model, marine waters, port infrastructure and the whole estate are under the ownership of the government through a mandated enterprise. The mandated enterprise is funded by the government to invest in ports terminal infrastructure and any other ports enabling infrastructure such as railways and road networks to the ports. Port management models Table 2.1 confirms that marine services like port control, pilotage, berthing, dry dock, or ship repair etc are executed by the mandated enterprise, however private business can offer the same services. Government also permits private operators to lease some port precincts and infrastructure to operate within the scope of their licence. The mandated enterprise staff oversee private business when handling cargo aboard vessels on the seaside (Min et al., 2017).

2.3.1.3 Landlord Port

Its essence prescribes that the government setup an authority enterprise and mandated it to act as a landlord for the ports. Port infrastructure is the responsibility of the government through authority enterprise therefore, its maintenance and management are high in the port management agenda. In Table 2.1 of port management models, the government oversees investments, management of the authority enterprise resources in port operation, parallel to reducing the dispersion of state resources allocated for port development (Khiem, 2017). This increases the value for money for state projects in the port system. Private operators are allowed to lease terminals for cargo handling and port operations.

2.3.1.4 Private Service Port

As demonstrated in Table 2.1, this port model is characterized by private port developers that invest, own, and control port infrastructure. Private developers enjoy maximum flexibility and

are authorised to increase the scope of their business across the strategic location of the port, since government involvement is limited for this model. Private port developer looks after a full range of services, starting with the purchase, management, and operation of all real estate inside the port, to solutions of handling cargo and container depot (Havenga et al., 2017).

Table 2. 1: Port Management Models

	Infrastructure	Superstructure and Equipment	Operations and Port Labour
Public Service Port	Public	Public	Public
Tool Port	Public	Public	Private
Landlord Port	Public	Private	Private
Private Service Port	Private	Private	Private

Source: World Bank (2001, p 75)

The cons of the port management model in South Africa resulted in Competition Commission prompting port users to express their unhappiness, citing issues such as operator and authority concerns, market power that limits competition, and the promotion of a unitary pricing system in which a single tariff book covers all Transnet commercial ports (Reuters, 2016). Diakomihalis et al. (2021) state that there have been numerous reports on port reforms. Competition for trades, concessions, commercialization, privatization, and various structural reorganizations of the public enterprise's contribution, such as state-owned ports operated by state owned companies, have all been taken into consideration during port reforms.

There is no multipurpose solution for port reform, as seen by how other countries' governance structures and South Africa is no exception. When implementing a particular reform approach, it is crucial to consider the economic and political environment in a republic like South Africa where ports are state-owned and prime terminals are managed by a government entity. The importance of ports in boosting the economy cannot be over emphasized in country with a staggering 32.9% unemployment rate (Trading Economics, 2022). The port management model in South Africa encourages a network of ports rather than port competition. The unified port pricing system, which applies a single price to all ports in Figure 1.1 and Mossel Bay, is not contested by the current port model. Meyiwa and Chasomeris (2020) point out, that appropriate regulation may be able to address the lack of competitiveness and monopoly power that linked with efficiency issues.

According to Meyiwa and Chasomeris (2020), South Africa is a developmental state that ensures public participation in governance, transformative processes, and the establishment of social cohesion with public through human rights and political organizations. Diakomihalis et al. (2021) opine that a government whose policies encourage and result in improved economic performance satisfies the definition of a democratic development state, hence Transnet Port of Durban management is public service model. Around 60% of exports in South Africa is processed at the Port of Durban and these cargoes are the lifeblood of the economy. The management of cargo movements into and out of ports depends heavily on TOS, as a result, freight traffic through the port has been severely disrupted, with trucks sometimes having to wait up to 24 hours to unload containers. Although Durban continues to be the entrance to South Africa, it has fallen short of fulfilling its promise to be the entrance to Africa.

All ports in Figure 1.1 and Mossel Bay are managed Transnet National Ports Authority which utilize a single tariff book and charging the same rates to ports with different facilities and target markets. The National Ports Authority was created to serve as a landlord of ports and to be accountable for the national ports infrastructure and system that it runs, monitors, and manages on behalf of the State. Table 2.1 Port Management Models illustrates industry models in which economic and political environment determines an effective model for a specific country. In South African context, Transnet use a public service port model where the TNPA and TPT are both controlled by DPE (World Bank, 2001).

2.4 Terminal Operating System (TOS)

The main objective of seaport platforms is to maximize the capacity use of the infrastructure to lessen bottleneck in the port and ensure sufficient flow of cargo. For the container terminal to perform better, all internal components that enable a port to optimize its processes are crucial. The components of a terminal like ICT system, port infrastructure, cargo handling equipment, and the performance of terminal operators are the pillars of an efficient port. TOS is the heartbeat of the terminal since it is the computational management system that oversees every operation carried out at the terminal (Heilig & Voß, 2017).

Globally, there are not enough off-the-shelf TOS solution providers. In no order, the established five are CITOS, Navis, Real-time Business Solutions, Tideworks, and Total Soft Bank which together cover about seventy to eighty percent of the off-the-shelf solution market. A researcher development augmented in Figure 2.1, Terminal Operating Structure account for at least forty to fifty percent of the total market (Boer & Saanen, 2014). The creation of proprietary TOS by major terminal operators to apply their TOS to all their facilities is a

consistent, if not growing, trend. Basic functionality is the identical throughout all TOS, even though each has unique advantages in terms of functionality, graphical user interface, and technological quality. Some vendors also offer advanced features such as berth planning, automatic stowage planning, equipment pooling and scheduling, and automatic container mooring. These functions are still not widely used in operations, despite their potential. It is anticipated to rise as terminals work to become more efficient.

2.4.1 Total Soft Bank (TSB)

TSB serves as the container terminal central system, automating an endless number of tasks that could not be accurately completed through manual labour. Terminal operating structure is a backbone of terminal operations and serves as a key tool for keeping records, planning, controlling, and monitoring at a modern port terminal. The tactical effectiveness, capabilities and strategic terminal viability, its clients, and operator are all significantly determined by the deployed TOS. TSB gives the port planning personnel the instruments they need to effectively assign equipment, give operators clear instructions, and adjust to unexpected changes (Hervás-Peralta et al., 2019).

The investment in a TOS, in terms of total container terminal investment and recurring costs, is very limited and typically represents less than one percent of a terminal's capital expenditure and two percent of its operating expenditure (Boer & Saanen, 2014). Nevertheless, the dependency on TOS is high and must therefore be considered mission critical. When a TOS is not functioning properly, operating costs increase, and the terminal's service level deteriorates.

TSB is used by freight forwarders, managers, port planners, port visitors, port workers, railways, regulators, shipping lines, supervisors, system analysts and terminal operators. A TSB's functionality extends beyond its technological prowess and excellence. However, it depends heavily on its interaction with users, such as planners, cargo coordinators, operators of overhead lifting equipment and administrative staff. Simultaneously, terminal operators are pushing for increased capability from their TOS providers, in part because to their desire to abandon manual planning and scheduling methods in support of more process automation. This extra feature makes the software even more complex, raises the possibility of instability, and thus causes operational outages. Thus, it is not surprising that current practice indicates that TOS installs and upgrades can result in certain limits and performance difficulties if not managed effectively, even with the best of intentions from software developers and future users.

2.4.2 Realtime Business Solutions (RBS)

RBS processes to all transit-related activities, from the time they arrive until they leave the port area. It is intended to manage terminals, oversee container deliveries, storage, loading, and unloading operations. It facilitates the management of assets, personnel, and cargo across the port. It guarantees that errors are discovered right away. By minimizing the time and effort required to serve outside entities like trucks, trains, and ships, it improves the efficiency and throughput of a terminal (Pelevic et al., 2022 May).

Every time the TOS is offline for any reason, the entire operation is interrupted, it results to a chaotic terminal operation with no systematic accountability. The terminal operations process so many different sorts of transactions at once such that reconciling them manually would take a significant amount of time, far longer than it would take to sort the issue, and get the system operational, ready to execute transactions. RBS is capable to handle huge volumes of data at the container terminals to update all transactions that were manually processed. The effective running of a container terminal is subject to the TOS utilization (Hervás-Peralta et al., 2019). It is obvious that without a TOS, there may be a significant loss in efficiency, like an end-to-end operational process in the container terminal. RBS seen as the primary means of increasing efficiency as the container terminal operates around-the-clock and is extremely susceptible to being lost. Operations at container terminals include highly coordinated and synchronized activities.

2.4.3 Tideworks

Tideworks manages the cargo transit within the terminals. Using this software, terminal managers may keep an eye on a variety of operations taking place at a port terminal and optimize the speed at which container ships are loaded and unloaded. (Hervás-Peralta et al., 2019). These tools assist terminal managers in managing the intricate day-to-day operations that include trucks, cranes, trains, ships, different kinds of cargo, and port personnel. Tideworks is used by cargo terminal employees to schedule ships and equipment, monitor cargo container movement, maximize yard space allocation, and make choices based on up-to-date terminal operations information. This TOS can interface with other software, such as Enterprise Resource Planning systems, that is utilized in the logistics industry.

Ports that have deployed Tideworks mostly integrate their legacy system with ERP system to enable faster system processing, more flexibility, process standardization and better business planning (Hervás-Peralta et al., 2019). While ERP systems are mostly used in the

manufacturing sector, the concept of ERP is also applicable to container terminal operating system. The integrated database was created with the goal of reducing duplication while maintaining integration and efficiency in data handling.

2.4.4 CITOS

Computer Integrated Terminal Operations System (CITOS) is another well-known TOS used in the Port of Singapore. CITOS address crucial terminal operations including berth allocation, stowage planning, and resource allocation as it integrates with many modules and expert systems (Kim & Lee, 2014). CITOS can be combined with other technologies and systems to track goods inside the terminal and transmit information with third parties. CITOS manage the yard activities and movement of the cargo. Selecting a system to use requires careful consideration of factors such as land costs, available technology, experience levels, as well as the workforce's comparative productivity (Renken et al., 2018).

To assimilate the significance of a TOS in a container terminal, think of it as the terminal's new heart when it is implemented for the first time or replaced by a new one (Hervás-Peralta et al., 2019). One of the most difficult undertakings a terminal operator will ever take on, implementing a CITOS system in a terminal requires a lot of work on the operator's part. The use of a commercial TOS can benefit terminal operators of all sizes greatly. Even relatively small terminals can significantly reduce the quantity of manual procedures, improve reporting capabilities, increase data accuracy, improve relationship with business associates and, in general, simplify their business processes.

2.4.5 Navis

The TOS primary purpose is to enhance port performance by enabling terminal operation structures specific to the port. Figure 2.1 shows how a highly sophisticated ICT system like Navis is embedded in the case of Transnet Port of Durban. Maritime supply chain is a very competitive industry, as a result, seaports must be operationally flexible, maximize productivity when loading and unloading container to be profitable, and successful. Sea ports are striving to automate terminal operations to streamline their processes and increase productivity. The crucial component is optimization of the terminal operations backbone system enhances safety, lowers manual errors, and boosts output and equipment usage (Pelevic et al., 2022 May).

Navis is by far a leading provider of port operations technologies and services that boost performance and efficiency throughout the ports in the global logistics chain (Heilig & Voß,

2017). It enables its customers, regardless of the kind of cargo, to boost productivity and reduce risk by fusing cutting-edge technology, industry best practices, and unique services. Navis customers experience better visibility, velocity, and quantifiable business results because of its all-encompassing approach to operational improvement. Heilig and Voß (2017) postulate that Navis assists in streamlining operations by automating equipment operations, rail network planning and asset use, improving vessel safety and cargo capacity, tracking cargo through a port, and managing many terminals with a single, integrated system. Navis is the industry benchmark for terminal operating systems, serving more than 250 clients across more than 50 countries (Transnet Port Terminals, 2013a).

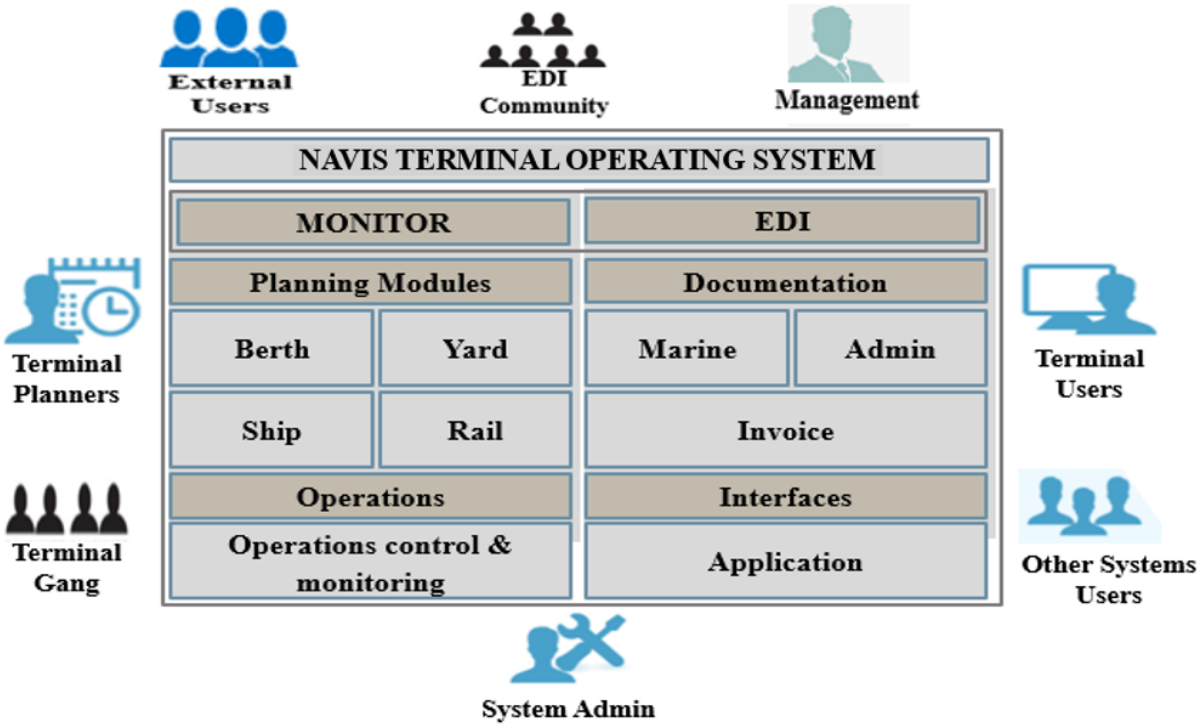

Figure 2. 1: Terminal Operating Structure
Source: Authors Own Design

Heilig and Voß (2017) state that Navis is the market leader now, it has been used by numerous large terminal operators worldwide and offers comprehensive options of customizing the TOS to meet requirements of terminal operators. The development of modules by TOS service providers has improved the planning and administration of terminal operations.

With its optimization features, the Navis system assists in increasing efficiency. The Transnet Port of Durban's primary operating system module, Navis Sparcs N4, manages operations using a variety of fully integrated ICT technologies for business support. As demonstrated in Figure 2.1, Electronic Data Interchange (EDI) delivers numerous sorts of communications and

streamlines communication with shipping lines, freight forwarders, customs and all other parties involved. System Applications Products (SAP) is a program that integrates finance, control, and management with modules for sales and distribution, materials management, and human resources.

No other TOS can compare to Navis's capacity to plan, organize, and optimize the management of equipment and containers in a complex business context. The only terminal operating system that allows for increased scalability to optimize terminal operations using ICT infrastructure while removing excess operational costs is Navis (Pelevic et al., 2022 May). The seamless integration of Navis Sparcs N4 with open architecture makes it simple to add new applications and combine them with already-existing systems. As it tracks technological advancement, Navis TOS streamlines terminal operations.

According to Notteboom and Rodrigue (2023), the Navis smart technology allows terminals to improve planning, visibility, and asset utilization for all players in their eco-system by releasing and monetizing the massive amount of data being collected in and around their terminals, including landside and on the coastline. No matter the operational style, all terminals make the best possible use of their available resources. With the use of Sparcs N4 optimization tools in Figure 2.1, terminal operators may boost productivity and automate decision-making across a range of critical operational and business processes. Sparcs N4 optimization modules take a thorough approach to optimizing processes in order to guarantee that land, labour, and equipment are used as productively as feasible. (Heilig & Voß, 2017).

2.5 Factors Contributing to the Efficiency

Information system that supports planning and management tasks pertaining to terminals are frequently referred to as TOS. Similar to the idea behind ERP systems, a TOS offers a collection of tools for gathering, storing, managing, analyzing, and sharing data from various terminal operations in order to give an integrated picture of key terminal operations and guarantee the effective use of resources for cargo handling. As a result, the integration of new applications, information systems, and other technologies into a container terminal is the main emphasis of a TOS. Additionally, many supporting technologies are used to manage and keep an eye on the cargo flow. Furthermore, it is necessary to facilitate data interchange with outside parties like shipping lines, agents, forwarders, truck and rail companies, governmental authorities like customs, and port authority (Heilig & Voß, 2017).

Along with ERP capabilities, standard TOS offer tools for supporting decisions, like advanced planning and scheduling modules and simulation tools. Automation in container terminals can be considered to be built upon the TOS, which houses all work orders for partially automated terminal procedures. (de la Peña Zarzuelo et al., 2020). Typically, ERP is distinguished by an automated database, integrated industry best practices, integrated applications, an open architecture, and an enterprise-wide framework encompassing all business operations and information resources. Planning facilities, such as berth and yard planning, are at the heart of ERP for container terminals (Heilig & Voß, 2017). Data flow from customer organizations such as shipping companies is combined with planning capacity. The ERP addresses the current operational problems of container terminals, which are mostly brought about by incomplete or erroneous data from client organizations, ad hoc and inadequate planning skills, and a lack of integration of a terminal's full information resources (Heilig et al., 2020). Not only can the ERP approach address issues with container terminals, but it may also encourage the adoption of information systems for container terminals.

In order to efficiently monitor the flow of items within, outside, and surrounding the terminal, terminal operating systems make use of other technologies including radio frequency identification (RFID), wireless local area networks (LANs), and EDI processing. Typically, real-time wireless transmission of system data to the central database (Min et al., 2017). Finding a container fast, evaluating if it has to be inspected by customs, and figuring out whether it needs special handling because it contains hazardous items, etc. The information gathered can be used to provide insightful reports on the state of the terminal's equipment and other objects. A TOS supports every essential procedure in a terminal, such as equipment control, gate management, ship planning, and yard planning. (Hervás-Peralta et al., 2019). Along with supporting information flow, TOS also handles the information needed for billing during a container's visit to the terminal. Therefore, it can be thought of as the terminal's pulse, and it is essential to its functionality.

2.5.1 Equipment

Ports depend on overhead lifting equipment to successfully carry out its operations, some of the equipment are Straddle Carriers (SCs) Rubber Tyred Gantry cranes (RTGs) and Rail Mounted Gantry cranes (RMGs). The choice of terminal equipment deployed in the yard is connected to capital investment, throughput, storage yard and stacking capacity. RMGs are the overhead lifting equipment with the widespan that are commonly utilized at port terminals for operations within container stacks. RMG equipment models are capable of manoeuvring in

dedicated rail tracks to allow for perpendicular loading and unloading by the crane side. RTGs equipment are used for arranging containers in the stacking area to manage the container stacks. Equipment performs the preparation of the containers to be in accordance with the location of a container in the terminal operating system and reflect accurate block, slot, row, and tier where the container is located. The SCs equipment are operated to load or unload trucks, transfer, and stack containers from the side of the quay to the stacking area. This equipment is capable to stack containers up to four (4) high.

Equipment has critical implications for the success of ports and important policy consequences. Given the growing competition amongst ports and the critical role that container transportation plays in preserving the maritime supply networks' ability to compete, additional experimental research can make a significant contribution to the discussion on port policy. Terminal management understand the reasons behind the choice of TOS better, which ultimately determines if it becomes the terminal of choice for port users (Gekara & Nguyen, 2020). When choosing a particular TOS, a port operator has to select from a range of alternatives for either automated or human systems. The decision influences the choice of equipment such as RMGs, RTGs and SCs to be used in terminal operations. The question arises as to what factors are critical in deciding for one TOS against another. The decision for a particular TOS is tactical and depends on a number of variables. Nearly all of the research on this subject has been done from a technical perspective, a review in Stahlbock and Voß (2008), while there is insufficient investigation on the key strategic factors leading to TOS preference. A lot of consideration is around storage yard, stacking capacity and equipment costs, because it can influence the choice of TOS, however this may vary from one port to another.

2.5.2 Container Terminal

With the advent of automation in container terminals over the past two decades, several new operational technology alternatives have opened-up to terminal operators. On the one hand, the drive to increase efficiency and reduce labour costs has led container terminals to explore automation options. Meanwhile, many container terminals still prefer more conventional terminal operations approach over concerns of system dependability and workforce adaptability. However, the concerns have been studied primarily from a technical perspective, using operations investigation techniques and sophisticated modelling however there has been a limited research on key drivers of terminal operating system choice (Hervás-Peralta et al., 2019). This is because these decisions are influenced by elements and problems that are

challenging to investigate due to data being classified, for instance, the costs of land in ports because it is a national key point.

The most important factors in the choice of TOS have been the availability of storage yard, stacking capacity, and equipment cost. Existing literature has discussed these issues in detail. Ability to stack is a critical influencing element in the decision of TOS in container terminals where storage yard is limited or has high-cost implications (Lee & Kim, 2013; Carlo et al., 2014b). At container terminals, RMGs or RTGs are usually used due to the excessive stacking of their capacity. In other container terminals where there are no storage yard challenges, SCs are preferred equipment to handle containers because of their high flexibility and affordability. Thus, if in a first step, operational activities are limited due storage yard and stacking capacity result into some equipment handling options being preferred or not. In a second step other factors such as terminal site and available workforce have a role in selecting the majority of appropriate TOS (Renken et al., 2018).

Historically, the efficiency of ports has been assessed by comparing several parameters, such as real maximum rate of production during a given time frame at berth (Cahyadi & Sugiyono, 2021). Figure 2.2 depicts the conceptual sequence of events at a container terminal, from the moment of cargo discharge to the point of cargo loading into the hinterland via the next mode of transportation. The seaside area is backside of the berth front, between the container yard and the quay wall. The yard is the zone where loading and unloading of these units happen in the terminal, which is a storage and or stacking area where the containers are kept. The landside operations area, that consists of the designated entrances, office block, car park, customs building, the warehouse with a material that is used to fill containers or protection of cargo from loss or damage during transit. The most frequent operations in the port are the loading and unloading of vessels using cranes like ship to shore, straddle carrier, rubber tyre and rail mounted gantry. There is a staging area where a lot of rearranging takes place in accordance with TOS in the yard, as well as container loading and unloading operations before loading containers onto ships, trucks, or trains to the storage yard.

2.6 Efficiency of Transnet Port of Durban

Transnet Port of Durban is the biggest port in the country with 14,930 TEUs per hectare. However, in global comparison China’s Shanghai is superior by six times per hectare in TEUs. The container volumes handled by the largest and busiest port in South Africa is smaller than in international comparator ports. Hence, a crucial part of a terminal, TOS’s main function is to control the movement and storage of a range of commodities within and around a container

port (Min et al., 2017). A TOS is intended to include a collection of electronic actions to handle inventory, equipment, and persware to enable efficient and effective operation of the terminal (Jungen et al., 2021). A schematic of Figure 2.2 demonstrates how TOS enables smooth operations, from the preparation of high-priority vessels to the execution of equipment and work orders (Min et al., 2017). Nevertheless, there are currently not many TOS solutions on the market that offer true real-time capabilities (Renken et al., 2018). Therefore, this study attempts to fill the literature gap in this regard by investigating the efficiency of TOS in improving port management of cargo handling at Transnet Port of Durban. Transnet ports mainly use Navis TOS, but no study is known to have investigated the efficiency of this TOS and its capacity to maximize Transnet scheduling and supervision of equipment and container movements at port terminals.

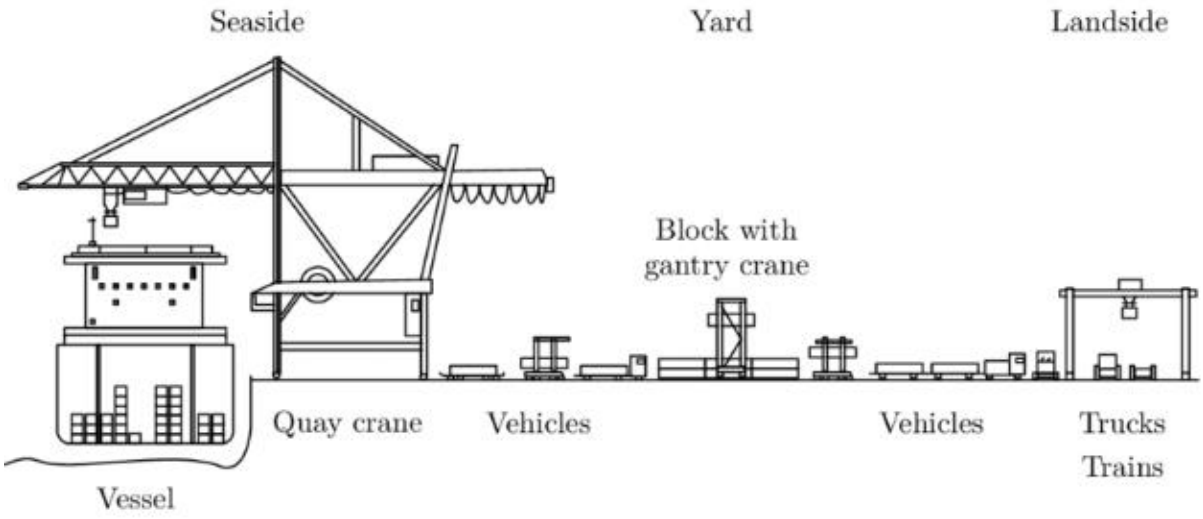

Figure 2. 2: An illustration of a container terminal in schematic form
Source: Steenken et al. (2004)

2.6.1 Seaside

Seaports are facilities that links container ships at sea with trucks on land as well as rail or inland waterways (Nishimura, 2020). At least three operational sections make up a seaport (Steenken et al., 2004) as shown in Figure 2.2. The terminal port operation is made of the berth operation, vessel operation, yard operation and gate operation activities. The planned arrival of the ship and the necessary equipment, such as quay cranes and seaside, are core activities of the berth operation. Getting the vessel turned around at the seaside as quickly as possible is the key goal of the berth operation in terms of efficiency at the port. The use of quay cranes to load and unload cargo onto and from the vessel by gang members constitutes the vessel operation.

In order to achieve optimal port performance, the primary objective of vessel operating is to maximize the number of containers handled per hour.

A vessel must first be docked along the berth to conduct seaside operations. A ship to shore crane removes a container from the ship once it has docked and discharge operations start. The container is then either placed on the ground for the Straddle Carrier to pick up and move, or it is placed onto the back of a hauler for hauler-based operations and moved to a stack in the yard (Gharehgozli et al., 2016). A cargo controller inputs each container's serial number into a handheld computer terminal (HHT), which updates the TOS database to generate a sequence for the next move.

2.6.2 Yard

A straddle carrier removes a predetermined container from the stack and places it beneath the ship to shore crane to load the vessel. A hauler works by removing the container from the rubber tyre gantry crane and driving beneath the vessel to the shore crane, which transports the container and places it inside the vessel (Schwientek et al., 2020). While the TOS receives data from the discharge operation to start the process, it is the TOS that uses work instructions to direct the load operation process. A vehicle mounted computer terminal (VMT) in Figure 2.2, also known as a mobile data terminal, is located within the rubber tire gantry, the straddle carrier, and the hauler. It enables the operator to utilize the TOS to receive work instructions.

2.6.3 Landside

The urge to expand landside operations and provide liner services has increased because to the growth of global businesses (Haralambides, 2017). Ports must purchase specialized equipment in order to handle containers and offer shipping companies container handling services (Bichou et al., 2007). Operational activities both on land and at sea need to be well coordinated in order to be effective and efficient. This is because tasks like loading and unloading containers onto and from ships, as well as transferring containers from the intermodal hub to the container terminal, are closely related and interdependent. Container port operators should make investments in cutting-edge information systems to connect maritime and land-based operations in an integrated system in order to increase operational efficiency. The port community's organizational relationships have seen substantial changes over time due to technology advancements, particularly for those who are committed to growing their market share.

Gekara and Nguyen (2020) determined the following interorganizational linkages amongst the various participants in the container transport chain as:

Shipping line–inland transport operator: Companies that provide road transport and shipping together have a stronger association now. To cooperate closely with road operators, shipping corporations often designate a restricted number of truckers to manage road transportation. Line-haul intermodality has arisen as an extension of liner shipping, with line operators controlling freight and rail operators synchronizing their services with scheduled vessel arrival timings.

Terminal operator–shipping line: The current development of network-based management has helped to the development of closer interactions between terminal operators and shipping corporations. However, from the terminal operators' perspective, the purchase of terminal services is limited to a few large shipping lines, which results in the shipping lines having a great deal of bargaining power. This phenomenon affects the operation of all port categories, be it feeder ports, hub ports, and or direct call ports.

Shipping line–freight forwarder: Many shippers choose an independent cargo forwarder since shipping lines may find themselves in a conflict of interest when proposing transportation services to their shippers. As a result, shipping lines must see cargo carriers as clients and continue to rely on cargo carriers and their shipper connections in order to expand.

2.7 Capacity of the Ports

Renken et al. (2018) posit that the maritime cargo trade plays an important role in global commerce because it enables governments to transport massive amounts of merchandise from one region of the world to another at extremely low costs. As ship owners are concerned about maintaining modest costs in the market, ports have shifted their focus to efficiency and profitability. Ports are becoming more profitable as they increase their efficiency and reduce the cost of their terminal operations (Stahlbock & Voß, 2008). Such efficiency and effectiveness rates affect the other aspects of the economy in one way or another. Consequently, cargo handling capacity and the resulting cost of port cargo, as well as vessel turnaround time, influence cargo owners' decisions regarding optimal transportation choices.

The ports are key engines for economic growth and intermodal transportation system. South Africa's geographical location presents a huge opportunity for the ports as is positioned on one of the major international sea routes, which is vital to the international transportation network.

Ports are dedicated sites that provide resources for berthing ships, and where there are quay cranes for handling ships to shores or shores to ships. According to Robinson (2002), ports serve as locations where vessels and freights from different parts of the globe are handled. Robinson (2002) further states that ports are economic and management structure that handle ships and cargoes in an economically efficient manner. Transnet Port of Durban is the major port on the coastline of South Africa.

2.7.1 Location

As an important component of the transportation infrastructure, ports are meeting points that connect to some inland transportation types such as freeways, railroads, and inland waterway systems (Zeng et al., 2020). Ports not only operate as portals for trade but also attract industrial operations and representatives of commercial infrastructure, such as financial institutions and insurance agencies. This has led to a trend toward logistical integration in ports (Dooms et al., 2013; Felício et al., 2015). Ports have transformed from cargo handling centres to distribution centres with physical facilities that act as transportation nodes in container supply chains. As such, they are becoming a link between the sectors of production and consumption attracting the attention of market players in the shipping and logistics business.

2.7.2 Interconnection

The expansion of worldwide enterprises has put strain on liner services and expansion to landside operations (Haralambides, 2017). Ports must invest in specialized equipment to offer container handling services to shipping corporations (Bichou et al., 2007). To be effective and efficient, operational activities on the seaside and landside must be well coordinated. Container transfers from the intermodal hub to the container terminal, as well as the loading and unloading of containers onto and from ships, are closely related and interdependent activities. Container port operators should invest in cutting-edge information systems to connect seaborne and landside activities in an integrated system. In the past, technological improvements have significantly changed organizational relations within the port community, especially those that are determined to increase their market share.

In addition, ports are the link between container terminal operators and shipping companies are critical stakeholders in the worldwide container transportation chain. (Zeng et al., 2020). Container terminal operators oversee everything from receiving containers to loading ships, managing containers to unloading ships. Container terminal operators also engage in activities such as ship stowage yards and coastal development. Shipping companies, on the other hand,

manage container ships and offer shippers liner services. Shipping firms collaborate with feeder operators, road carriers, rail operators, logistics service providers, and terminal operators to give shippers door-to-door and integrated logistics services.

2.8 Research Modelling

The purpose of the research model is to give significance and applicability to the study findings. Establishing a synergy in theoretical frameworks enables the integration of discoveries into a coherent structure to make project discovery more usable to others. A researcher's research model assisted in developing the research instrument to extract data, analyse and get reliable outcomes. In pursuit of Navis TOS efficiency, the same data may have been collected at the Transnet Port of Durban, however if a different research model had been used, it is most likely that it would have been represented differently. The use of AST, TTF, and TOE frameworks assisted the researcher to sort his thoughts and coordinate the way the data would be represented. The presence of the research model is important in assuring the research is given structure and reach finalization in a way that could clearly be communicated to its readers (Transnet stakeholders, especially those with vested interests at Port of Durban).

The underlying connection in performance changes has been challenging to demonstrate in the port literature. Adabere et al. (2021) posit that in ports, performance assessment systems often measure either internal efficiency or outward efficiency, but seldom both dimensions are captured. There are numerous examples of ports around the world that run well but are nonetheless inefficient, and vice versa, thus this study considered six models of information systems to investigate the efficiency of the operating system of the Transnet Port of Durban. These models are Adaptive Structuration Theory (AST), Task-Technology Fit (TTF), Technology-Organization-Environment (TOE), Technological Frames of Reference (TFR), Theory of Technology Dominance (TTD) and Socio-Technical Theory (STT). The purpose is to examine the function of information systems in enhancing operational systems in cargo handling.

2.8.1 Related Models

Spieth et al. (2021) defined how TFR direct the information and its assumptions on organizational members interpreting and using IT. Technological frames recognizes that various groupings have perceptions of the efficiency, significance, and usefulness of technology. Since understanding how organization members use technology plays a key part in organizational transformation programs into influencing their behaviour and obtaining

desired results, TFR theory is not ideal for exploring efficiency of Navis TOS at the Transnet Port of Durban.

Sutton et al. (2022) posit that TTD influence the organizational behaviour, decision-making, and performance depend on task complexity and experience in technology. The usefulness of technology lead to an organization becoming more data-driven, with decisions being based on available data than desired operational output. While according to Buchanan (2019), STT prompts user acceptance and continued utilization of technology because every enterprise is made up of interdependent subsystems. The two theories are not the best fit as there are capable individuals who share common cultural beliefs and conventions, follow determined procedures, and use deployed technology in every enterprise.

2.8.2 Adaptive Structuration Theory

AST models how organizational structures and technical improvements are combined. The AST concepts of "Group Decision Support Systems" (GDSS) structures the construct of IT-facilitated social interactions as "Input → Process → Output Sequences" (DeSanctis & Poole, 1994). This theory investigated mutual influence of technology and social practices, consequently the structure is a result of how context and technology interact with one another as shown in Figure 2.3.

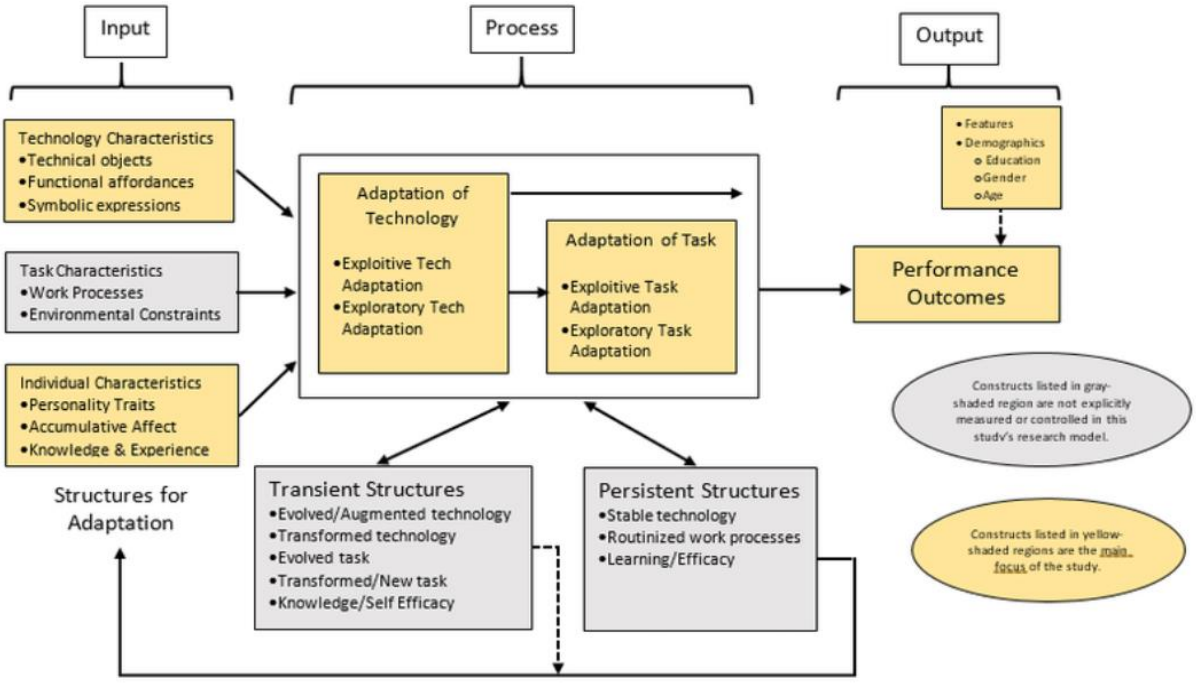

Figure 2. 3: Adaptive Structuration Theory for Individuals
Source: Schmitz, Teng & Webb (2016)

This framework was developed and proposed primarily because of the importance of capturing the complexity of flexible use of information technology by individuals, not just by groups and teams, including those who are not technical users. The framework in Figure 2.3 is intended to provide a more detailed description of user behaviour. All adaptation elements are classified and divided into adaptation of technology and adaptation of task (Kim et al., 2014). Nonetheless, technology influences the intellectual and behavioural involvement of individuals to the extent that their technological interpretations can lead to actions that affect the strategic and structural direction of the organization (Jungen et al., 2021). This organizational change relies on gang members driven by some change agents, terminal operation events to accomplish their tasks using Navis TOS. So, it is necessary to constantly evaluate the individual drivers for work and organizational activities and find out how they will manage them (Yeo & Marquardt, 2015).

2.8.3 Task-Technology Fit Model

Task-Technology Fit (TTF) theory makes an appropriate collection of collaboration technology capabilities with a specific group activity and context that are meant to improve efficiency with Navis TOS. The activities at the terminal operations level are split into tasks, the whole list of tasks amounts to section or shift activity. Although there are variations in these fundamental structures across the available theories, the TTF theory in Figure 2.4 provides precise descriptions of each construct, including function, technology, context, and nature of fit for information systems in port operations. Patterns indicate how particular management and gang (team) member behaviours that affect how efficiently, or inefficiently gang members perform in terms of TTF. Individual behaviours, procedures, technology, and tools all fall under these practices. The TTF model illustrated in Figure 2.4, explains the use of IS by organizations based on the postulation that the value of a system depends on the effectiveness with which the system supports users in performing the specific tasks for which it was developed (Carlo et al., 2014b). According to Idemudia and Raisinghani (2014), TTF theory postulates that the effective use of a given technology depends on its ability to meet the needs of the user. Therefore, the technology must have features that support adaptation to the task at hand.

According to Goodhue and Thompson (1995), TTF theory is mostly expected to improve individual accomplishment and can be adopted if its expertise matches the tasks that the user must execute. The proponents of this theory recommend a few characteristics that gauge task-technology fit, such as the technology's quality, usability, system dependability, and profitability in terms of the time and money spent providing the service. The Port's IS such as

Navis TOS that process all transactions of port commodities, greatly benefits from using this paradigm. TTF model is suitable for gang member when a performance is aligned with tasks to be executed. Figure 2.4 shows that the task-technology fit is a product of three main elements, namely task characteristics, technology characteristics, and individual characteristics. Task characteristics include concepts such as knowledge tackiness and task interdependence, while technology characterises the elements of compatibility and quality (Carlo et al., 2014b).

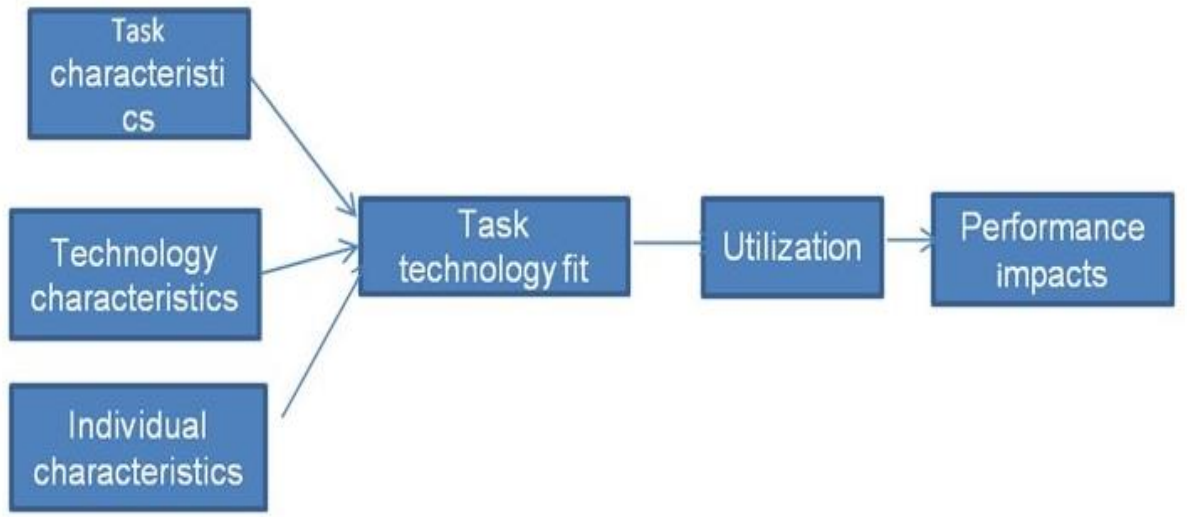

Figure 2. 4: Task-technology Fit Model
Source: Goodhue & Thompson (1995)

2.8.4 Technology–Organization–Environment

Finally, the third model used in researcher's research model design is the TOE theory, which focuses on three aspects: technology, organization, and environment. The technological context outlines that acceptance depends on the selection of technologies inside and outside the Transnet Port of Durban, including the relative gains, compatibility, complication, trialability, and monitoring of the application. The organizational context includes the Port of Durban commercial outlook, executive support, Transnet culture, complexity of administration hierarchy as defined by grading, ratification, and standards of people management (Kim et al., 2014; Tornatzky & Fleischer, 1990). The environmental context promotes and prevents issues in the parts of terminal operations where the actual TOS is deployed. In the main are competitive pressures, collaborations with business associates, sociocultural issues, government support, and technological infrastructures (Zhu & Kramer, 2005).

Previous research has shown that the TOE model is effective in terminal operation system with wide applicability and explanatory power in a variety of technological, technical, and

educational contexts. The TOE model has been used to demonstrate interorganizational systems, e-business, electronic data exchange, open systems, enterprise systems, and a wide range of generic information systems applications. In most industries, especially port terminal operations, the TOE model has been used to define how innovations are accepted. Numerous studies have indicated that the three factors of technology, organization, and environment influence how an enterprise perceives the necessity for, seeks out, and acceptance of new technologies as an efficiency driver.

In the empirical study testing the use of TOE paradigm, researchers applied slightly different criteria for technological, organizational, and environmental context. In this study, the researcher has agreed with Tornatzky and Fleischer (1990) that the three TOE contexts in Figure 2.5 influenced acceptance, but feels that for each technology or environment studied, there is a unique set of characteristics or measurements to be explored. For example, Yeh et al. (2015) argue that "technology readiness" is a significant feature in the technological context that influences e-business acceptance. Similarly, these scholars propose that "business size", "global reach", and "financial resources" are significant features to examine when considering how the organizational context influences e-business acceptance. It is evident that every enterprise has technology embedded in its operations to maximise efficiencies. The Transnet Port of Durban has Navis TOS as the backbone of terminal operations to maintain and grow customer service.

Like any other theory, TOE has its weaknesses. The fact that the TOE framework has not evolved or changed since its inception may be due to several factors. First and foremost, the TOE framework shown in Figure 2.5 has been referred to as a "generic" theory (Hendricks & Maple, 2023). Considering that the theory has not evolved but is used as a framework inside which a variety of other features can be placed, this judgment seems acceptable. The TOE framework is highly flexible because it gives the choice to modify factors or measures for a particular research environment. Therefore, scholars have no desire to modify or advance the theory. Secondly, the TOE framework is seen as compatible with existing theory explanations for innovation acceptance instead of providing a matching description.

The misalignment in TOE framework and other theories is noticed as insignificant, and the strain is overcome by the flexibility of TOE framework to embrace other concepts instead reacting to them. For example, the TOE framework has been shown to be compatible with Rogers's theory of diffusion of innovation. It is assumed that the organizational contextual factor of TOE is comparable to the predictors of innovation diffusion, individual leadership

qualities, and inner features of the organizational structure. Outer features of the organization related to diffusion of innovations are similarly equated with the environment of TOE. Finally, it is argued that the technological background of TOE is equivalent to Rogers's implied significance on the technological qualities of innovation (Yeh et al., 2015)

The TOE framework was changed in response to the diffusion of innovations not because these theories are described as strikingly comparable, but because scientists say they are related. The integration of TOE with an EDI adoption model exemplifies how the TOE framework incorporates a comparable theoretical approach. The EDI adoption model was created through a research program with multiple case studies and describes how perceived benefits, organizational preparation, and external pressures influence EDI acceptance. Some take it a step further, noting that following Tornatzky and Fleischer (1990); Oliveira and Martins, (2011) model that has been developed formulates three aspects of EDI acceptance: the technological factor, the organizational factor, and the environmental factor and integrates the EDI adoption model into the framework of TOE.

The environmental aspect in Figure 2.5 is about the operational environment of the company. In the environmental context, threats posed by competitors must always be examined, to guard against being behind with the latest technologies that competitors are using. The framework of TOE considers the environmental aspect, which is not included in AST (Dedrick et al., 2015).

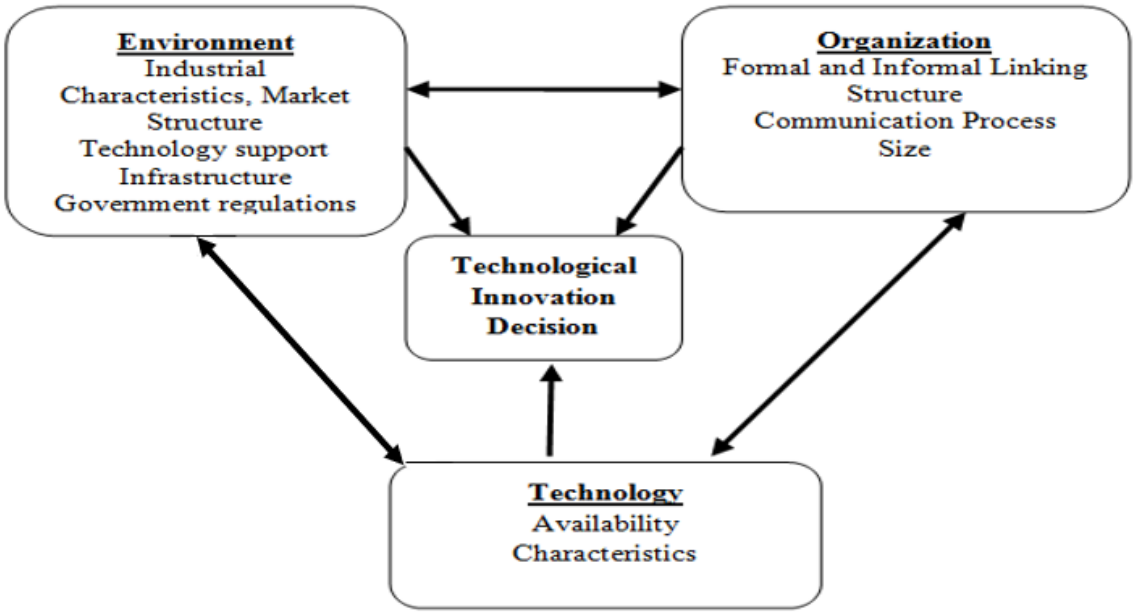

Figure 2. 5 Technology, organization, and environment framework
Source: Tornatzky & Fleisher (1990)

Research on the variables for the examining efficacy of TOS within the ports is relatively new. Therefore, for the intentions of this research, a paradigm for evaluating issues related to the introduction of a TOS technology from the literature review is used.

2.8.5 Research Model

To support the premise that a solid research model can help the researcher uncover predispositions about a study and aid in data coding and interpretation, previous work is synthesized. This simple premise is supported by the understanding that leaning too heavily on a model might result in other types of complications. Task–technology according to the fit theory, improved performance might result from a good fit between the technology, the task, and the team (Howard & Rose, 2019; Park, 2019; Goodhue & Thompson, 1995). But over time, teams frequently change how they carry out a task. TTF contends that only when technology's capability is matched to task needs will it have a favourable effect on performance (Goodhue & Thompson, 1995). In information systems, performance issues are linked to inadequate technology fit. TTF has often concentrated on the task characteristics, the technological elements, and how these two fits together to effect performance.

Guided by the variables of the theories discussed above, a research model that integrated AST, TTF and TOE models was developed for this research. As shown in the research model in Figure 2.6, the study aims to examine how the integration of technology resources (represented by the relationships between business capability and performance characteristics in relation to technology adoption decisions) contributes to the efficiency of TOS in cargo handling. Finally, the study explore how Transnet Port of Durban system procedures complement the terminal operating system performance in cargo handling. This will be done by evaluating the interrelationships between the organization with procedures, the technology with tasks, and the environment with culture in terms of performance and productivity.

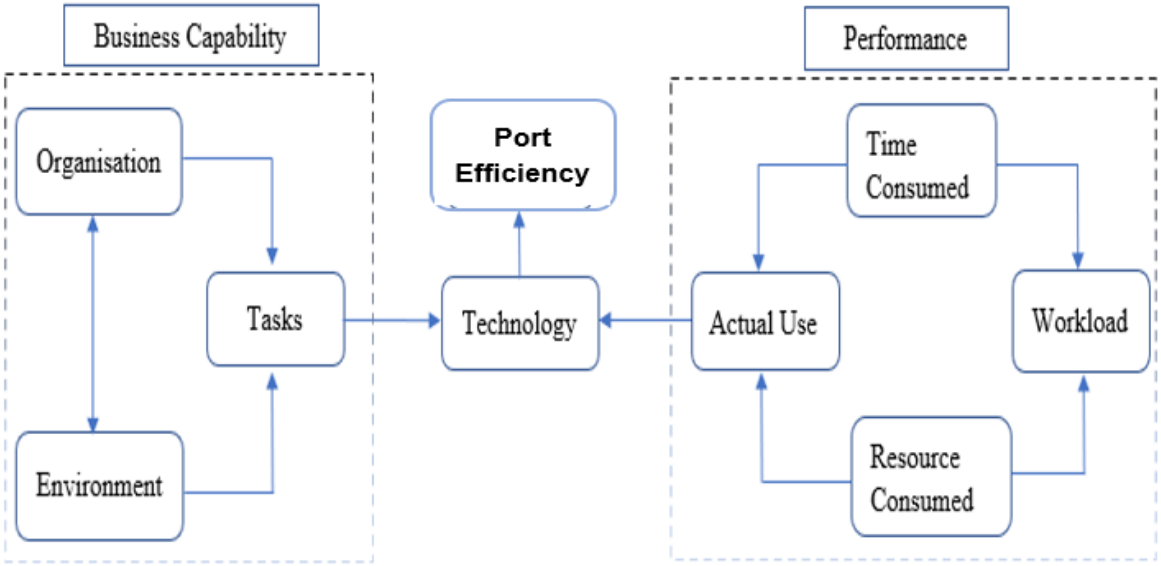

Figure 2. 6: Research Model
Source: Authors Own Design

The technological, organizational, and environmental factors of an organization all affect the adoption and use of technology. They include new and existing technologies applicable to the business. These factors fulfil critical role in business accepting a decision as it determines the business ability to take advantage of environment management initiative (Min et al., 2017). Hence, TOE model continues to provide significant information systems perspectives for scholars. The conflicting theories must be attended to so that the concepts informing these theories are aligned and fitted into the TOE framework. Therefore, scholars must systematically investigate competing concepts and if it is found acceptable, enhance the TOE framework (Yeh et al., 2015).

According to Hervás-Peralta et al. (2019) scrutinizing how techniques of one's behaviour and acceptance can impact the TOE framework's justification of organizational implementation is another avenue for theoretical evolution. Researchers have argued that studies of adoption ought to consider more than the technological, organizational, and environmental context because task characteristics and individual aspects are equally important (Awa et al., 2016). Maybe a combination can be achieved that merges the qualities of these theories in outlining individual behaviour with the strengths of the TOE framework in defining organizational behaviour. Technology use is emphasized as a key element in determining technological impacts, while the structural potential of technology is also considered. Schmitz et al. (2016) postulate that AST is a flexible and can concurrently influence the gang members at the terminal operations yard.

2.8.5.1 Business Capability

Container terminals oversee the movement of cargo between a port's landside and seaside. Heilig and Voß (2017) argue that there are three main operational areas that make up a container terminal: the seaside area, the yard operation area, and the landside where truck and train operate. Quay cranes, stacking cranes, and transport vehicles such as automated guided vehicles, straddle carriers, and multi-trailer systems are utilized to aid various categories of vessels and to meet shipping lines' demands for an effective port operation. Advanced planning is necessary for the effective administration of ports and its infrastructure and equipment. Making decisions about berth allocation, stowage planning, and crane split are all part of ship operations (Heilig & Voß, 2017). Storage design and stacking choices are crucial to a terminal's performance in the work area of cargo handling, which separates operations on the landside and the seaside.

2.8.5.1.1 Organisation

The organizational context in this study relates to the features and resources of the port terminal, including internal communication protocols, the size of the terminal, the other resources, and connection mechanisms between terminal gang members, planners, and other system users. These resources interact in a variety of ways that affect how Navis TOS is used and how quickly it operates. According to Awa et al. (2016), the most crucial organizational context variables are financial resources, innovation capacity, operational capability, organizational slack, terminal structure, technological resources, top management support, and infrastructure. Additionally, organizational communication practices can support or hinder effective technology utilization (Navis TOS).

2.8.5.1.2 Environment

The environmental context, among other things, refers to the requirements of business partners and consumers, authority bodies, the legislation, and government organizations that influence technology utilization (Awa et al., 2016). Disregarding these dynamics could result in penalties and the loss of potential commercial prospects. Additionally, because of the dynamic nature of the environment, players in the market attentively observe other players and imitate their behaviour to stay competitive. It happens frequently that businesses adjust their programs to fit existing practices that may have been established using the same principle to the point where it creates an infinite cycle of retaliation (Felício et al., 2015). Competition among terminals increases the possibility that technology will be used, and when this competition is intense, a full utilization of technology gives terminals the competitive edge to increase port efficiency.

2.8.5.1.3 Tasks

There are several primary performance metrics in container terminals that are available to evaluate the daily administration of the terminals for planning purposes. (Jungen et al., 2021) argues that the common metric for cargo handling efficiency is crane movements per hour. Container dwell time is another port efficiency metric that is commonly used due to port constraints (Gekara & Nguyen, 2020). Dwell time for imports refers to the period a cargo spends on the terminal yard, from the moment it is released from a ship to the moment it is removed from the port gates. Berth time is a component that can have a significant impact on a ship's turnaround time if it is reduced (Gekara & Nguyen, 2020). In terms of yard occupancy, it is possible to divide the container yard into several slots for the purposes of stacking containers. To achieve optimal efficiency in a port, the design and layout of the work area at the quay are extremely important (Kammoun, 2018).

2.8.5.2 Technology

Technology is now crucial to the efficient and timely transmission and processing of massive amounts of data in terminal operations environments (Steenken et al., 2004). For a port to operate effectively, all the systems (ERP, EDI, LAN, RFID, and HHT) linking to Navis TOS to process this operational information and transmit it to people in charge of managing Transnet Port of Durban must be managed properly. There is no TOS that compare to Navis' special capability to enhance the organizing and management of cargo and equipment moves at a terminal (Notteboom & Rodrigue, 2023). Navis N4 Sparcs is adopted in more sites than most TOS supplier. Navis N4 Sparcs expands with the business to maximize the utilization of IT infrastructure and avoid unnecessary, upfront capital expenses. The extensible N4 Sparcs architecture allows terminals to build databases and application server clusters, allowing TOS to scale to meet demand.

2.8.5.3 Port Efficiency

Port efficiency explores the capability of a port to get a maximum output with a given set of inputs or to use a minimum input for a given set of outputs. Efficiency improvements indicate that cargo handled by the port is increasing towards an optimal situation. Optimization of terminal resources increase port's productivity, and it is mainly driven by technology evolution. According to Min et al. (2017), port efficiency cannot be measured by a single metric but advancement of technology, organisation, and environment throughout a specified period.

2.8.5.4 Performance

Goode (2007) asserts that total logistics costs in South Africa are estimated to account for 15% of gross domestic product (GDP). As a result, these costs account for about three percent of high-value cargo and up to 50% of lower-value bulk cargo. Although they do not account for the largest share of total transportation costs, port operations costs alone are said to account for seven percent of the total logistics chain (Ibid). The high costs associated with a combination of performance, efficiency, and transportation in the national logistics network hinder the country's economic development. Zehendner and Feillet (2014) posit that ports should reduce cost of doing business through technology advancement, given the vulnerability of global trade and hostile cargo costs considering the location of the Transnet Port of Durban to major ports around the world. Therefore, over time, an efficient TOS will improve international trade to match global industry best practises (Ports Regulator of South Africa, 2015).

2.8.5.4.1 Workload

The planning and optimization of horizontal and vertical transport activities is required to facilitate an effective flow of cargo between all areas of operations. There have been a lot of research in efficiency of port operations methods and solutions developed recently because of optimizing port performance with the increasing port traffic (Lee & Song, 2017). The use of those techniques to assist in fast and economical decision-making strongly depends on information systems that provide correct information about the situation at hand. Additionally, management functions like booking, accounting, reporting, etc. are necessary for a port to be managed sustainably. These functions allow for the measurement of performance using key performance indicators, the facilitation of efficient information flows, and the provision of an integrated view of operations and resources or inventory.

2.8.5.4.2 Resource Consumed

The container number and its location in the stack are included in the information presented by the VMT, or work instruction, together with the directive to the operator to go and pick it up. The operator updates the TOS with the VMT after completing the pick-up. Some terminals can also issue work orders through voice commands allowing the operators' hands to be free to focus on the steering controls. The architecture of the data terminals provides visual proof that operators must have easy access to and interaction with the TOS (de la Peña Zarzuelo et al., 2020). The contact is further streamlined by delivering straightforward instructions that only call for a small number of responses on the data terminals, which operate on well-known

operating systems like Windows. These streamlined exchanges have the intended effect of making activities highly dependent on the ICT system.

2.8.5.4.3 Actual Use

Cargo is discharged from the vessel during yard operations, and cargo is loaded into the vessel using a variety of yard equipment, such as straddle carriers. Out of sequence cargo is then re-stowed, and cargo is strategically placed for optimum utilization of the yard. The purpose of the finest yard operations is to ensure yard flexibility through good landside management and hinterland connectivity, which will reduce cargo dwell time and allow enough capacity for additional cargo handling at the port. Gate operations comprises of coordination activities of a location where freight forwarders transport cargo to be loaded onto vessels and serves as the arrival point for cargo that are received as imports from the vessels that are calling to the port destined for various depots into the hinterland.

2.8.5.4.4 Time Consumed

Due to growing cargo volumes, the demand for lower transportation fees and the efforts of shippers to reduce transportation costs per shipping unit, ships have become larger and faster in recent years (Min et al., 2017). In addition, for economic reasons, shipping companies are increasingly seeking to optimize ship handling by shortening layover times in ports. This situation is prompting competing terminal companies to invest in cutting-edge loading and unloading technologies, as well as terminal renovations, to reduce the time ships spend at their ports. In the fierce competition between container terminals, efficient terminal operations are another crucial factor for improving competitiveness and productivity (Hervás-Peralta et al., 2019). However, compared to the massive investment in terminal expansion and infrastructure plans as per Transnet shareholder compact, software systems for efficient terminal operations and standardization are not prioritized.

2.9 Summary

Chapter Two of this study laid the background of the methodology used to determine the level of TOS efficiency in container terminals. The researcher explored various variables related to information systems using AST, TTF, TOE, TFR, TTD, and STT theories to understand the terminal operating system and the general background of container terminal operations. The researcher presented an overview of the ports in Figure 1.1 including Mossel Bay that are managed by TNPA through a public service port management model. The chapter gives a detail

breakdown of the TOS and how serves as a key tool for keeping records, planning, controlling, and monitoring at a modern port terminal.

A task-technology under-fit means that an organization is not using its capabilities effectively, thus limiting its ability to achieve the intended benefits (APM Terminals, 2015). The organization that has excessive capabilities but cannot exploit to enhance efficiency is technology over-fit for tasks. Furthermore, organisations that are task technology over-fit have invested too much in IS technologies. Carlo et al. (2014b) opined that the best IS technology is the one that has the best task-technology fit, hence the study is looking at the efficiency of Navis TOS at Transnet Port of Durban. A high degree of fit between task and technology contributes to better performance. This aspect stems from the fact that a employees can perform tasks more effectively and efficiently. The cost of performing tasks also decreases satisfactorily (Idemudia & Raisinghani, 2014). Fundamentally, this chapter also showed a researcher's preferred research model for this study that was developed from the integration of AST, TOE and TTF models.

CHAPTER THREE – RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter discusses the research procedures used in carrying out this study. The chapter presents a blueprint of how the thesis was conducted, from beginning to end. The researcher discusses research design, various research procedures, sampling techniques, data gathering and analysis, and ethical considerations (Creswell, 2014). According to Saunders et al. (2019), research is an organized process with clear goals for gathering data with the idea of advancing understanding of a certain matter. The goal of this study was to use scientific inquiry to get reliable conclusions on how the Navis Terminal Operating System can increase efficiency. By analyzing port terminal operations using conceptual models, and legacy information systems, the research studied the important input of productivity factors from a terminal operating system approach with the goal of increasing the efficiency at the Transnet Port of Durban. The study also performed a sensitivity analysis utilizing secondary data to identify key performance variables driving efficiency of the port. The researcher used a "research onion" model to explore the efficiency of the Navis Terminal Operating System at Transnet Port of Durban.

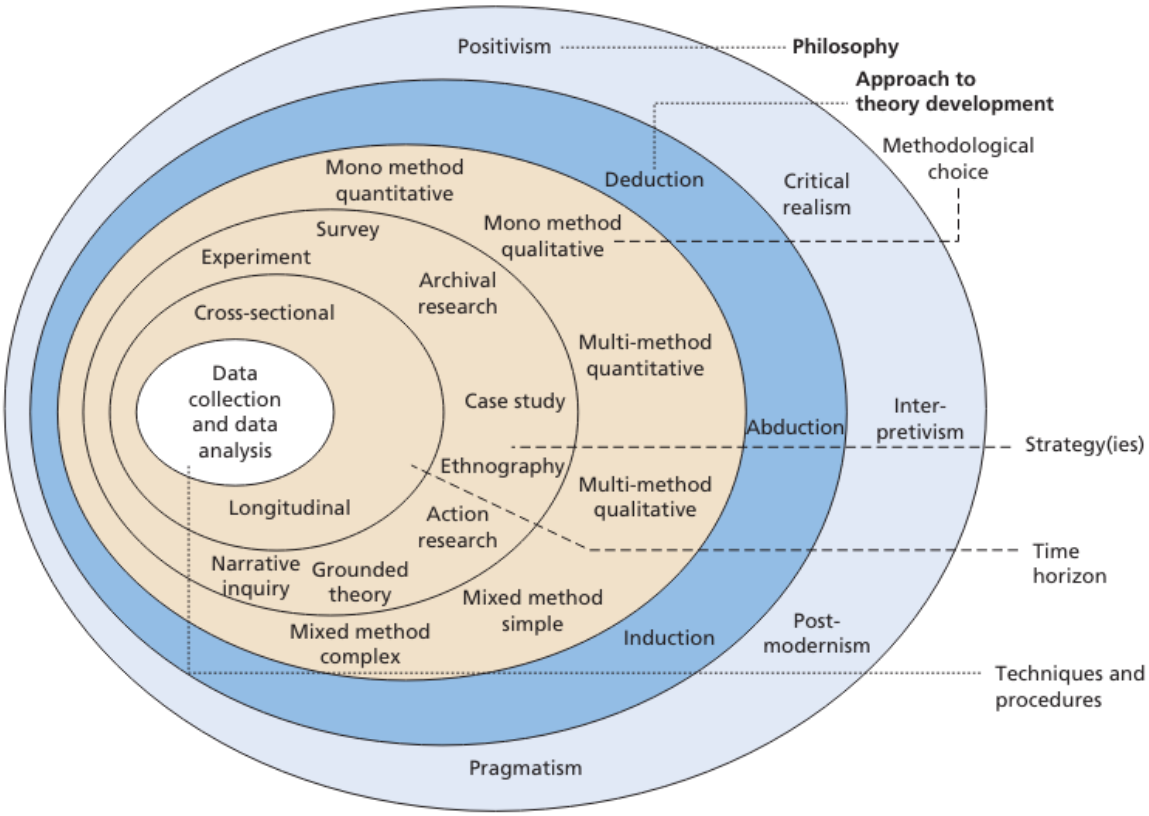

Figure 3. 1: The "research onion" model

Source: Saunders et al. (2016, p. 124)

3.2 Research Design

According to Van Wyk (2012), the research design is a methodical process of inquiry that enables the research aim to be clearly attained. Van Wyk (2012) further accentuates the requirement for research evidence that supports the theory rather than research findings that are consistent with theory. Saunders et al. (2019) state that research design is the strategy for conducting research that considers the methodologies, strategy, and theoretical approach that are appropriate for the research topic. As Snyder (2019) outlined the importance of literature review as a research method, the researcher in this study formulated an approach to address the research questions presented in chapter one using research methodology as guidelines. The strategy includes information on the sources and procedures for gathering data, as well as analytical and ethical issues. Saunders et al. (2019) posit that the research design offers generally three methods, qualitative, quantitative, or a mixed method for collecting data. Correlational research, descriptive research, explanatory research, and exploratory research are some examples of research designs (Snyder, 2019).

3.2.1 Correlational Research

The purpose of correlational research is to find relations between greater than two items in the same population or between the same things in two distinct populations (Leedy & Ormrod 2019). Identifying the relationships between numerous factors is an important aspect of any study. Understanding the relationships among "human phenomena" is a consistent drive for scientific inquiry in all social science disciplines, and this drive overcomes even the most polarized paradigmatic divisions among different research approaches (Rubin & Babbie, 2016). Mohajan (2018) distinguishes between (a) independent and dependent variables and (b) experimental and correlational procedures in quantitative research methods. The manipulation of items distinguishes experimental designs or methods, whereas correlational designs or methods evaluate attributes of the same individual that are greater than two and then determine the correlation between them. Correlational study aims to determine how closely variations in one characteristic or variable are related to variances in one or more other characteristics or variables (Leedy & Ormrod, 2019). If one item (X) is increasing while another (Y) is decreasing, there is a correlation. A correlation value of 0.00 means that there is no link between the items under study.

3.2.2 Descriptive Research

According to Snyder (2019), descriptive research pattern can assist solve questions such as who, what, when, where, and how they connect to a particular research problem, but they

cannot tell you why. Descriptive research is used to learn about the current state of a phenomenon and to characterise what "exists" in a scenario in terms of variables or conditions. Descriptive research focuses on the "what" question and is not mostly perturbed with reasons (Snyder, 2019). It is found at the "midpoint of the knowledge continuum" (Aspers & Corte, 2019), amongst exploration and explanation. Descriptive research is used in both quantitative and qualitative research and can also be guided by inductive reasoning, which finds hypothesis from a particular perceptible experience to ordinary rules or knowledge development (Newman & Gough, 2020). Inductive reasoning, which starts with facts and the goal of making sense of it through thinking, generates theory.

3.2.3 Explanatory Research

Causal research explains the "why" question by describing the root cause of the status quo and seeks to unpack the root cause and provide a solution to the "why" problem (Pandey & Pandey, 2021). Explanatory research and testing have a direct relationship. Theory is examined by deductive reasoning, which progresses from broad to specific (Newman & Gough, 2020). For explanatory research, propositions serve as a framework for connecting the research goal to subsequent stages of the research process (variable construction, and data selection). They facilitate the alignment or reasoning between phases of the research process and provide ways to assess the study's advantages and shortcomings. Keep in mind that explanatory research might generate new queries that inspire exploration. Explanatory study is relational (A explains B). These connections are exposed by the explanatory research hypothesis. Explanatory models can take many different shapes, from process theories that explain things without making any claims, like practice-based perspectives, to variance models that explain things by making claims that can be tested statistically (Aspers & Corte, 2019). Snyder (2019) posit that theories with a causal explanation can also predict.

3.2.4 Exploratory Research

Interpretive research is usually seen as an inductive, qualitative process (Reiter, 2017). In comparison to quantitative studies that apply deductive confirmatory techniques, exploratory qualitative research is typically criticized for lacking methodological austerity and yielding preliminary results. (Reiter, 2017). Exploratory research is a form of investigation that is in its initial stages, it is exploration (Baŝkarada & Koronios, 2018). It is linked to coincidence, innovation, and exploration. However, the explorer is also the one who describes the activity of exploration. It often happens when a researcher investigates a new interest or when the research topic is still quite recent (Reiter, 2017). As a result, inquiry has a flexible nature that

prioritizes pragmatism and biographically specific interests of the researcher. Pearse (2019) argue that exploratory research is normally perceived as inferior to confirmatory or hypothesis-testing studies. In this study, the issue with that is because we live in an era of technology systems often changing and what is settled now is likely to be uncertain and in need of exploration soon. Additionally, exploratory research develops topics that will be examined in more in-depth studies and provides initial insights into the nature of a problem (Reiter, 2017; Snyder, 2019). Because all study subjects were once new, exploration is mostly relevant, and every study subject has the potential for innovation or continued novelty.

An exploratory design is utilized to investigate a subject when there is little or no prior research to cross-reference to or rely on to anticipate the results (Pandey & Pandey, 2021; Reiter, 2017). The exploratory design is used to determine the outcome of the research. The aim is on gaining knowledge in planning for future investigation or in investigating research challenges in their early stages. However, explanatory research aims to improve knowledge by creating valid explanations that might also be useful for prediction (Baŝkarada & Koronios, 2018). Exploratory designs are typically used to determine the best strategy for conducting a study or the most successful procedure for acquiring data on the subject (Snyder, 2019). For this study, it is suitable to do exploratory research to determine whether a phenomenon exists (Saurama & Julkunen, 2011). There is no compelling evidence that Transnet Port of Durban has fully adopted the Navis TOS paradigm into a single, easy-to-use tool for the efficient planning and decision-making phase of management for a fully customized and optimized information system, for this reason, the exploratory research design has been used for this study.

3.3 Research Philosophy

Philosophy of science is a set of beliefs about how to collect, examine, and apply evidence for a phenomenon as demonstrated in Figure 3.1. Saunders et al. (2019) state that the research point of view is aimed at developing knowledge. Van Wyk (2012) stresses the need of determining the kind of research results required prior to choosing the research technique and issues a warning against associating research strategy to data gathering approach being quantitative or qualitative. This suggests that the study methodology should be chosen based on the anticipated findings. Saunders et al. (2019) posit that the theoretical perspective methods are positivism, critical realism, interpretivism, postmodernism and pragmatism.

3.3.1 Positivism

Philosophy applies statistical or quantitative techniques rather than qualitative techniques, must be theorizable, concentrate on stable independent variables, and make specific ontological

assumptions (Baŝkarada & Koronios, 2018). The researcher's role in positivist studies is limited to acquiring data and independently analyzing it. Positivism assumes that realism is constant and can be observed and defined accurately, i.e., without intruding with the phenomena under investigation (Baŝkarada & Koronios, 2018). Baŝkarada and Koronios (2018) believe that events should be separable and observations repeatable. This frequently results in modifying reality with only one independent variable to identify regularities and establish correlations between specific aspects of the social realm. Predictions can be made based on previously observed and described realities and their interrelationships. Positivism shown in Figure 3.1 is a historical movement with an extensive and well-known history. It is extremely rooted in our culture that knowledge assertion not based on positivist philosophy thinking are rejected as unscientific and therefore invalid (Nzabonimpa, 2018).

Numerous scholars have called for a more pluralistic approach to information systems research methods (Archibald, 2016; Rubin & Babbie, 2016). There has been a lot of discussion about whether this positivist paradigm is appropriate for the social sciences (Nzabonimpa, 2018). Although the researcher is not explaining in details on this discussion, it is relevant to this research because information systems is regarded as a social science rather than a natural science since it is about the collaboration of individuals and technology (Nzabonimpa, 2018). Actually, in some instances the problems in information systems research, such as visible contradictions in results, might be related to the inappropriateness of the positivist paradigm for this field. Likewise, some components of certainty could be considered as unmeasured under the positivist paradigm and thus were not explored (Newman & Gough, 2020).

3.3.2 Critical Realism

Philosophy of perception is a social science that holds the same view as positivism that there is reality, both natural and social, which is independent of human understanding (Mingers et al., 2013). Accordingly, critical realism accepts the idea that all beliefs are socially produced but rejects the idea of judgemental relativity. There can be no basis for favouring one set of beliefs over another, hence all views and statements are equally valid (Creswell, 2014). Critical realism presented in Figure 3.1 is an overarching theory, initially developed from a popular theory of science called transcendental realism and a super precise human science theory called critical naturalism (Dobson, 2012), through connecting an explanatory thread to a profound ontological attitude that is conceptualized mostly from the natural sciences. The goal of critical realism is to discover the collection of mechanisms that underlie a particular phenomenon. A researcher must first have knowledge about a specific occurrence to build a theoretical account

of the existence and consequences of a specific set of mechanisms that would lead to the specific phenomenon as stated (Saunders et al., 2019). Fundamentally, critical realists assert that social actors' perceptual and cognitive processes are affected by a tangible, mind-independent reality (Vandenberghe, 2018). Dobson (2012) posit that there are three spheres of reality, according to critical realism, which expresses this more directly. The empirical domain relates to our experiences, the actual and real domains to the outcomes we experience directly or indirectly encounter, and the real domain to the generative mechanisms that result in these and other related occurrences.

To create this explanation, one must rely on pre-current cognitive resources and work under the guidance of something like a logic of analogy and metaphor to develop a theory of a mechanism that, if it functioned as proposed, might explain the phenomenon in question (Mingers et al., 2013). The mechanism's reality is next examined empirically, and the hypothesis' empirical suitability is maintained in comparison to that of alternative explanations. The generative mechanisms are structured material and immaterial entities, such as other procedures and experiences, that have simple powers that can be partly started by the meaning that people assign to them and that can be discovered by people's intentional or unintentional, rational, or irrational actions (Dobson, 2012). The external macrostructures to which they belong continue to determine how a mechanism will ultimately behave. Multiple structures and their ensuing generating mechanisms interact and work together to generate a macrostructure (Mingers et al., 2013). Consequently, certain mechanisms support or negate others. The mechanisms and powers of an underlying stratum are employed to produce each stratum as well, thus each level has its own structure and powers because of a developing process brought on by the collaboration of its different parts (Vandenberghe, 2018).

3.3.3 Postmodernism

Postmodern constructivism is a philosophy that describes a variety of practices, incidents, and views in relation to art, architecture, the humanities, and the social sciences that started in the later stage of the twentieth century (Saunders et al., 2019). According to Vandenberghe (2018), postmodern philosophy illustrates instances of major historical and ideological upheaval in which modernist narratives of development and social holism are regarded as incomplete, elastic, and contradictory, in contrast to modern culture, which focuses on social progress, coherence, and universality. Postmodernism included in Figure 3.1 is a philosophy that opposes the concepts of reason, objectivity, and absolute truth (Vandenberghe, 2018). Instead, it emphasizes the diversity of ideas and the human experience. Younger generations and more

educated people alike have grown accustomed to gathering knowledge from a multitude of sources since the introduction of technology. These generations continue to doubt the veracity of what others have informed them even though most of the information gathered may be erroneous. They prefer to seek out the truth on their own. The core of postmodernism is the urge to find one's own truth (Storey, 2021). Vandenberghe (2018) argue that there is no choice but to adopt this new perspective as a method of eschewing exclusive, rational ways of thinking in favour of a more cohesive, adaptable, and creative environment. It is critical to consider postmodernism as the base upon which modern systems are constructed.

Williams (2013) postulates that the essence of knowledge cannot remain intact in a setting of general change, because technology is always changing the content of the knowledge possessed by society. In the context of postmodernism, culture is more than just a collection of facts, but an activity that creates meaning for the world by building it rather than just presenting it. According to Storey (2021), in postmodernism, each person has the capacity for self-determination and the right to do so. Truth used to be an established fact that each generation acknowledged as being true. They believe that postmodern thought makes the definition of truth less evident. Rather than relying on the truth accepted by their parents, government, or church, postmodern people base their results on their own research, unique experiences, and interpersonal relationships. Postmodernists may define truth differently, but it does not imply that postmodern people do not believe in it (Williams, 2013).

3.3.4 Pragmatism

To accomplish the study goal in pragmatism philosophy, mixed methods research permits for the exploration of both quantitative and qualitative approaches. Some of the pragmatic philosophy's advantages include its mixed-approach data gathering method, which enables the acquiring research material in both qualitative and quantitative method. It gives researchers the chance to use several research approaches and mechanisms that are ideal to gather data associated to their aim rather than being restricted to a single methodology. Additionally, it supports a variety of perspectives, premises, and data analysis methods (Creswell, 2014). Pragmatism argues that we can still have valuable knowledge even though we must always be aware that our knowledge claims may turn out to be wrong to avoid the sceptical or relativist response to the lack of perfect certainty. According to the pragmatic model, there is a disconnect among the naturalistic methods and free-flowing orientation of more modern approaches and the scientific technique and structuralist orientation of older systems (Creswell, 2019; Creswell & Clark, 2017).

While truth and reality are controversial metaphysical concepts, the pragmatist research paradigm excludes them. Instead, it recognizes the possibility of either a single reality or a plurality of realities that can be explored empirically (Creswell & Clark, 2017). Scholars, who maintain the pragmatic view, have said that there is an objective reality that exists apart from human experience. This reality, which is based in the environment, can only be experienced through human connection (Kaushik & Walsh, 2019). A fundamental principle of pragmatic philosophy is that knowledge and reality are based on socially constructed beliefs and habits (Wills & Lake, 2020). According to pragmatics, all knowledge in our world is socially constructed, while some of these social inventions more closely represent people's experiences than others (Kaushik & Walsh, 2019).

Pragmatism included in Figure 3.1 offers a profoundly grounded perspective on human activity that relies on the reciprocal capacities of action and reflection as its foundation. The meaning can be expressed through the development of habits and the identification of experience patterns, communicated through communication, or externalized either implicitly or explicitly in writings, objects, technologies, practices, or social conceptions. Other phenomena are positioned just as we are and draw on our collection of routines and experiences. These phenomena include other human agents, but they also include technologies and settings that have been designed as instruments and techniques for coping with the world's emerging phenomena.

3.3.5 Interpretivism

Interpretivism is in line with qualitative research, which uses open-ended questions to interact with individuals to understand the context and complexity of environments. The supporting and participating perspective is qualitative and collaborative in essence, enabling involvement with study participants from the start of the study through the analysis phase, creating consistent study discoveries that will bring about change and improvement in the environment (Mohajan, 2018). The philosophy of interpretivism has its origins in hermeneutics, which deals with the theory and practice of interpretation (Baŝkarada & Koronios, 2018). According to hermeneutics, to reconstruct the intended meaning of the text, interpreters must endeavour to immerse themselves in the author's vision or thought process. Interpretivism is a softer and subjective manner of evaluating evidence. It is sometimes called "anti-positivism" or "naturalistic inquiry". Constructivist epistemology pertains to interpretivism, and according to this viewpoint, individuals do not have access to the real world in their thinking, thus their

knowledge of the perceived world is meaningful and may be recorded by interpretivist procedures. (Archibald, 2016).

The primary constraints of interpretivism are the subjective character of the technique and the large possibility for researcher bias. This is due to data being frequently impacted by personal opinions and values, primary data gathered in interpretivist studies cannot be generalised. However, the advantage of interpretivism is that qualitative research topics, such as cross-cultural differences in organizations, issues of ethics, leadership, and the study of factors influencing efficacy, can be examined in great depth. Since primary data acquired by interpretivist studies are usually reliable and authentic, they encourage a high degree of validity. It is for this reason the interpretivist approach shown Figure 3.1 is appropriate for this study because it examines the phenomenon of the efficiency of a TOS in handling cargo at the Transnet Port of Durban.

3.4 Theoretical Approach

Abductive approach consumes a lot of time because it needs the researcher to be thoroughly engaged for adaptation (Mitchell, 2018). Qualitative research utilizing an inductive technique is not favourable to a priori theory or improving on existing bodies of knowledge (Pearse, 2019; Saurama & Julkunen, 2011). This is simply because inductive approach depends on participant experience do analysis.

As stated in Pearse (2019), deductive approach permits theme design for the coding process to test the constructs described in the research model. Hence, research categories are beneficial for deductive descriptive research. When constructed intelligently and in reference to the literature, categories can serve as a framework to guide measurement, link to data collection methods, and aid in data analysis. Therefore, deductive approach is appropriate for this study because it can provide horizontal coherence throughout all stages of the research process.

3.5 Methodological Choice

Saunders et al. (2019) assert that the method choice consists of mono, multi and mixed methods. Mono method is utilized when the goal of the study is to collect either qualitative or quantitative data. Multi method challenges the application combines qualitative and quantitative methodologies, even when the research is based on one of them and the other is simply an extra method. Mixed method is utilized within the same study, quantitative and qualitative methodologies to achieve distinct objectives and control the limitations of using a single method.

3.5.1 Mono Method (Quantitative and Qualitative)

In quantitative research, many respondents are asked structured questions with predetermined alternative answers (Ngozwana, 2018). Under normal circumstances, quantitative research utilizes measurements, symbols, numbers, and statistics to describe the fundamental variables as well as to gather, analyse, and interpret data. Measurements ought to be "objective, quantitative, and statistically valid" (Kankam, 2019). More specifically in understanding that there are two types of quantitative research approaches: (a) the direct study of people and their conduct using surveys and questionnaires, across the board; and (b) the indirect study of people and their conduct using computer-simulated studies, statistics, and secondary data (Mitchell, 2018). One could argue the use of rigorous, computable techniques and applications is crucial to the accomplishment of a quantitative research approach.

Iyer and Nanyam (2021) asserts that qualitative research seeks to investigate and discover questions regarding the dilemma of interest. The efficiency of Navis terminal operating system has not been investigated since adoption at Transnet Port of Durban. Qualitative research was utilized to acquire an insight of the fundamental reasons, opinions, and motivations of the status quo at the Port of Durban. According to Aspers and Corte (2019), qualitative research is described as a detailed investigation of a topic of interest in which information is gathered by a researcher through, interviews, and participant observation.

In this study, a qualitative research approach in the form of open-ended questions is suitable to allow respondents to express their opinions as the study focused on the efficiency of TOS in cargo handling at Transnet Port of Durban. Furthermore, a qualitative research method is perfect for this research topic because it is successful when the sample size is small (Johnson & Onwuegbuzie, 2004).

3.5.2 Multi Method (Quantitative and Qualitative)

According to Kankam (2019), a qualitative research method entails a thorough exploration and analysis of the factors that influence a participant's conduct with regards to a specific issue. The primary distinction between qualitative and quantitative research is that qualitative research focuses on understanding factors that lead to specific conducts and experiences of participants. In contrast to the quantitative research approach, which explores the "what," "where," and "when," this research method seeks to identify the "why and how." (Ngozwana, 2018).

3.5.3 Mixed Method (Simple and Complex)

The mix methodology approach is the third research strategy. This research strategy brings both qualitative and quantitative research methods (Johnson & Onwuegbuzie, 2004). In addition, a mixed-methods strategy enables academics to use a broad and innovative approach rather than a restricted (Sekaran & Bougie, 2016). The essence of this research method is to describe, explore and comprehensively explain the object of research under study. This is the basic reason for its application.

3.6 Research Strategy

In a research process, design propositions about knowledge claims are changed into techniques or research strategies (Sekaran & Bougie, 2016). A research strategy is a methodical approach to conduct research and answer a question. It is essential to know the difference between research methodology and research methods. Methods include research methods, which can refer to specific procedures used to conduct a study. There are several classifications for research methodology. The term "research methodology" can point out to a research technique, a type of research, a research paradigm, or a research framework. The research methodologies are either quantitative or qualitative in nature, or a combination of both. Research methodologies give a defined structure, guide, or direction for research procedures in a simple form approach model (Sekaran & Bougie, 2016).

3.6.1 Research Method

A research strategy outlines the essential components of a research endeavour, including the study topic and focus, research perspective, research design, and research methodologies. It outlines how the researcher intends to answer the research questions and how the methodology will be navigated. The most commonly used research methodologies include case studies, qualitative interviews, quantitative surveys, and action-oriented research.

Qualitative interviews are a sort of research that collects data from a group of people to get knowledge and insight into a set of concerns (Saunders et al., 2019). Interviews in this study give the researcher the opportunity to follow up and clarify the participants' responses, which can enhance the validity and dependability of the findings. With the accessibility of new technologies, data collection through business communication and digital platforms such as social media or MS Teams is becoming more common (Bhattacherjee, 2012).

In this study, qualitative interviews will be used to explore a phenomenon of Navis TOS to determine its efficiency at Transnet Port of Durban. The researcher focus is on business capability to yield desired performance. Heilig and Voß (2017) posit that TOS is the heartbeat of the port, therefore technology is at the centre stage of the study. The study explores operational atmosphere, scope, and goals of Transnet Port of Durban in completing tasks to ascertain adequate business capability. In the context of this study, performance looks at the time consumed to complete a workload in relation to the resource consumed and determine the actual use. The technological aspect concentrates on Navis TOS that the Transnet Port of Durban uses in carrying out its operations. The adequate business capability with full use of available technology creates expected performance as demonstrated in research model Figure 2.6, to drive port efficiency in highest levels.

The research model of the study in Figure 2.6 collects the challenges experienced when performing operational tasks and strategies to reduce the ship berthing times is extracted in business capability to discover if the set targets are realistic. The research model reveals the reliability of deployed resources and adherence to preventative maintenance plans which reflects Transnet Port of Durban performance. The accomplishment of operational tasks is supported by the ability to understand and use available technology that feeds to port efficiency.

3.6.2 Population

Participants of the study are one (1) Executive Manager, one (1) Navis Consultant, two (2) Systems Engineers, two (2) Business Analysts from ICT department. The other participants are two (2) General Managers, and two (2) Terminal Managers from Operations department. These are "information-rich" participants the researcher intends interviewing to further explain, better understand, and explore research participants ideas, behaviours, and experiences at Transnet Port of Durban, to gather a richer source of information (Saunders et al., 2019). Interviews in this study give the researcher the opportunity to follow up and clarify the participants' responses, which can enhance the validity and dependability of the findings. To explore efficiency issues in more depth in this exploratory study, a qualitative interview with semi-structured questions to conduct investigation and explain the efficiency of TOS in cargo handling at Transnet Port of Durban.

3.6.3 Research Instrument

Research instruments shown in Appendix D were distributed via email and interviews were conducted online (MS Teams) to adhere to all Coronavirus disease of 2019 (Covid-19) protocols and to ensure no physical harm occurred. Each interview was captured using the MS

Teams audio recording along with handwritten notes. However, consent was obtained from all participants in order to record the interview, which would then be transcribed in order to gather additional information that might have been overlooked in the handwritten notes for analysis. The signed informed consent form included a section where the participant's consent was documented.

In-depth interviews are used for data collection, Appendix D – Questionnaire Part 1 Research Instrument Employees File was used for non-managerial employees and Part 2 Research Instrument Management File was used for managerial employees. The research instrument is categorized into part 1 and 2 to collect appropriate data from the technology-based and operations-based participants which is in line with their roles and responsibility at Transnet Port of Durban. Participants were allowed to respond to the research questions posed in the study with guidance (Crowe et al., 2015). Questions are compiled to be consistent with the research objectives and problem statement to ensure consistency. All sections (Sections B, C, and D) on both part 1 and 2 of the interview guide contained open-ended questions based on the goals or questions related to business capability, performance, technology, and efficiency. These sections contained a total of 50 questions that were consistent across all interviews.

3.6.3.1 Demographics (Section A)

The interview guide consisted of four main sections. Demographics are consistent on part 1 and part 2 of a research instrument and included questions about participant information to determine whether participants are eligible for the study and to confirm participant characteristics (e.g., their experience) during the interviews.

3.6.3.2 Business Capability (Section B)

In part 1 of a research instrument employees file, business capability that concentrates on difficulties employees face when performing tasks, how realistic are the set targets and what are the blind spots in operational processes. In part 2 of a research instrument management file, the focal point in business capability is the communication of tasks, techniques to improve shift productivity, and support strategies for underperforming employees.

3.6.3.3 Performance (Section C)

In part 1 of a research instrument employees file, performance focus on the frequency of performing preventative maintenance, the reliability of resources deployed in operations, and how standard operating procedures enhance resource efficacy. In part 2 of a research instrument management file, managerial employees deduce realistic preventative maintenance

intervals from the analysis of corrective maintenance, provide sufficient resources for operational tasks, and strategize to optimally operate at terminal capacity.

3.6.3.4 Technology and Efficiency (Section D)

In part 1 of a research instrument employees file, technology and efficiency closely look at the availability of operational technology to perform port operations tasks, how easy to understand and use the operational technology, and what are the causes of operational delays. In part 2 of a research instrument management file, technology and efficiency is about ensuring that available technology perform port operations tasks to perfection, investigating operational delays, and retention critical skills.

Qualitative research necessitates data of great richness, depth, and quality, and the research instruments employed in a study satisfy these criteria (Babbie & Mouton, 2012). The researcher used an interview guide as the research tool for this study and employed a semi-structured method to conducting interviews. This interview guide offered a regular set of subjects and questions to be addressed in the interviews, but it also allowed the research to investigate new opinions and themes that surfaced throughout the interview. Semi-structured interviews provided the researcher with the flexibility of an unstructured and open-ended interview as well as the directed guidance and agenda of a structured interview guide. In-depth interviews were considered appropriate to draw information on developed questions from respondents and to extract their opinions about the study. According to Royse et al. (2015), interviews are usually conducted on a face-to-face basis with participants who have experience or expertise on the topic.

3.6.4 Ethical Considerations

The goal of research ethics is to protect participants' dignity, rights, safety, and overall well-being. According to Totemeyer et al. (2014) ethical application ensures that the needs and interests of the parties participating in the research project are respected, considered, and serve to govern interactions between researchers and research participants. The following ethical guidelines were used when performing the study to make sure that the code of ethics was followed:

3.6.4.1 Ethical Clearance

Ethical clearance serves as evidence that the researcher is committed to proving that the study was conducted in an ethical way and is of high quality and integrity (Nazarczuk et al., 2019). The research proposal outlining the study's topic, purpose, literature review, and procedure

was approved after being presented to the School of Management, Information Technology and Governance in the College of Law and Management at the University of KwaZulu-Natal. The topic and site the project, research questions and objectives, methodology, interview schedule, informed consent letter, and gatekeeper's approval letter from Transnet SOC Ltd were all included in the application for ethical clearance that was submitted to the Humanities and Social Sciences Research Ethics Committee (HSSREC). The request was fully approved as shown in Appendix A (Ethical Clearance). The application was assessed by the HSSREC to make sure that none of the research participants rights will be violated or harmed.

3.6.4.2 Gatekeeper's Letter

Transnet SOC Ltd issued a gatekeeper letter, as per Appendix B. The researcher sent Transnet a letter asking for authorization to perform study on their site. The request letter emphasized the study's goals and purpose. It also described the type of study data that will be necessary, such as access to port performance records and in-person interviews. The letter outlined the significance of carrying out this kind of study and how the outcomes will benefit the organization. The highest levels of the organization's leadership examined and accepted this proposal.

3.6.4.3 Informed Consent

An informed consent form in Appendix C was made available to the respondents so they could read, understand, and sign it as a consent to take part in the study. Participants had access to the researcher's contact information. The participants also received the project supervisor's contact details. The consent form incorporated details of the study goals and concerns about anonymity and confidentiality. All participants were made aware that their inputs would be handled with the strictest confidentiality and that their identities would not be revealed. The consent form clearly indicated that partaking was optional and that participants had the right to quit the study at any moment. Finally, the form stated that taking part in the project would not result in any financial gain.

3.6.4.4 Acknowledgements

The participants were acknowledged for taking part in the study and advised they would receive the final report after the results were gathered at the conclusion of the research project. In conclusion, the researcher issued a declaration at the inception of the study project stating that this research report is the outcome of his own original research and that this project has not

been presented for examination or degree in any university. Most importantly, all concepts sourced from other researchers were properly cited.

3.7 Time Horizon

Saunders et al. (2019) states that among time horizons there are "cross-sectional" and "longitudinal" studies. The cross-sectional time horizon is defined as the "snapshot time horizon," while the "longitudinal time horizon" refers to the "diary perspective time horizon". Snapshot time examines a single topic at a specific point in time, while diary time horizon potentially spans a long period of time (Saunders et al., 2019). A cross-sectional research approach was used to gather data. This approach is appropriate for the study because the researcher is exploring the Navis TOS to determine its efficiency at this snapshot time.

3.8 Research Techniques

In line with research questions, the researcher selected a data collection strategy that will suit the target population. This was informed by a fact study area is premier port with most cargo handling activities in South Africa. The sampling method adhered to inclusion and exclusion criteria of the study with a sample size appropriate to establish the response rate.

3.8.1 Data Collection Strategy

Data collection is a methodical way of gathering thoughts and opinions to explain a phenomenon. According to Hayashi Jr et al. (2019), data gathering can be done in a structured or unstructured manner as it is an essential part of every research project. While unstructured research techniques, such as participant observation, are promoting the development of perspectives and ideologies, semi-structured interviews enable the researcher to study specific questions. Babbie and Mouton (2012) argue that in analysing data, the researcher should focus on to the "spoken words", the context, the reliability and inconsistencies of views, the quantity and intensity of remarks, their precision, emerging themes, and trends. In-depth interviews were chosen for data collection. Along with the interview guide, a consent form was written inviting potential participants to participate. The question guide was composed to be consistent with the research objectives and problem statement to ensure consistency. The data collected were analysed using thematic and content analysis.

3.8.2 Study Area

Transnet Port of Durban is the busiest and largest container port in the country. It is strategically positioned along an international shipping network which secured the port's relevance as being the main container port in the country that handles more than sixty percent of container cargo.

The study was conducted at Transnet Port of Durban because it the country's premier container port and the main port servicing the KwaZulu-Natal and the Gauteng provinces, as well as the Southern African Development Community surrounding area. The Transnet Port of Durban generally handles 4000 vessel calls per annum, which are highest port volumes in the country, estimated to be in a region of 61 million tons of cargo per annum.

3.8.3 Target Population

A research population is identified as a collection of study elements (such as people, artefacts, events, or organizations) from which data are gathered that form the source of investigation (Babbie & Mouton, 2012). This means that a population is the set of groups from which the research selects a segment to conduct the study. Thus, a target population is the specific group of individuals with certain characteristics in which the research is interested (Bryman & Bell, 2015). According to Frankel Pratt (2016), not all members of the population are necessarily part of the study's target population. Therefore, eligibility criteria must be defined to determine who qualify to be the target population.

The population comprises of one (1) Executive Manager, one (1) Navis Consultant, two (2) Systems Engineers, two (2) Business Analysts from ICT department and two (2) General Managers, and two (2) Terminal Managers from Operations department. The population was purposively selected given the level of expertise and decision-making authority in the field of the study. This is because phenomenological qualitative research like this study relies on the experience, insight, and intersubjectivity of the parties involved in the research (Basias & Pollalis, 2018).

3.8.4 Sampling Method

The probability and non-probability sampling methods are the two sample types in a study. The respondents are selected randomly in probability sampling, while in non-probability sampling respondents are purposefully selected. Inclusion and exclusion criteria are a set of guidelines that must followed to be included in a study. Probability sampling is a sampling technique in which a researcher randomly selects members of a population based on a set of criteria. Probability sampling techniques are established on statistical probability theory and are most linked with quantitative and positivist studies (Shannon-Baker, 2016; Wiid & Diggines, 2010).

3.8.4.1 Inclusion Criteria

The inclusion criteria establish target population focal points that the researchers will utilize to solve research questions. It precisely and impartially pinpoints the research population.

According to Wiid and Diggines (2010), non-probability sampling procedures do not allow for generalization beyond the set of sampling units and can only be judged subjectively. There are several non-probability sampling procedures, the popular procedures are: random sampling, snowball sampling, quota sampling, and purposive sampling (Kankam, 2019). In random sampling, researchers select any willing and available individuals as participants. The inclusion criteria were that participants must be based at Transnet Port of Durban, working in ICT and or Operations Departments, have major decision-making authority in Navis TOS, and with 10 years or more experience working in Navis TOS.

3.8.4.2 Exclusion Criteria

The exclusion criteria incorporate attributes that present enrolled population inappropriate for the study. In contrast, non-probability sampling processes are dependent on the researcher's subjective assessment, and the selection probability of the elements of the population is indeterminable (Wiid & Diggines, 2010). In snowball sampling, researchers select the first subject who meets the participant profile and then ask him or her to recommend other individuals with similar features. In quota sampling, researchers select individuals according to specific traits or qualities and individuals are not given an equal probability of being chosen to participate in the study. The exclusion criteria were, participants that are not based at Transnet Port of Durban, not working in ICT and or Operations departments, with no decision-making authority in Navis TOS and with less than 10 years' experience working in Navis TOS.

3.8.4.3 Sample Size

According to Johnson and Onwuegbuzie (2004) the sample size cannot be less than 80% to determine the appropriate response rate. Based on inclusion, exclusion criteria and sampling technique used in this study, the sample size is eight participants. The researcher subjectively and purposefully picks individuals based on a prepared list of inclusion criteria. Phenomenological and qualitative research is only effective when the correct participants are chosen (Kankam, 2019). This study uses a purposeful, non-probability sampling strategy to attain the intended effectiveness. This allowed the researcher to select only a "information-rich" participants from Transnet employees. The selected population had a significant insight, detailed knowledge, direct experience in TOS and it was reasonably certain that adequate and relevant Port of Durban information would be obtained (Creswell, 2014).

3.8.5 Analysis Process

The conducted interviews brought so much insight to the researcher about the Transnet Port of Durban, and the themes in Table 4.1 emerged. The section B, C and D of research instrument

(for both part 1 and 2) collected data on the field for business capability, port performance and technological infrastructure in this study to explore efficiency at Port of Durban. Following the Creswell (2019) six-step analysis process, qualitative data was examined in the following ways:

Management and arrangement of data analysis involved transcription of recorded data obtained from semi-structured MS Teams interviews digital recordings, which also included interview notes made during the interview. This information was categorised and put into different groups for familiarisation. According to Peel (2020), a researcher should become familiar with the data collected from participants to enable an in-depth understanding of data gathered.

3.8.5.1 Naming the Themes

As the second phase, at this point the researcher became familiar with the data and came up with ideas regarding its content, most notably the significant elements of it. In this phase, ideas, patterns, and relationships are generated and extracted from the data collection (Williams & Moser, 2019). The development of basic concepts, patterns, and connections were informed by the research objectives and were clearly identified for ease of reference. This procedure was aided by NVivo software for qualitative data analyses (Williams & Moser, 2019). The use of NVivo in this study made it easier to create labels that highlight significant data characteristics related to participant responses to the research topic. Relevant codes and snippets were compiled after the interview transcripts had been coded.

Following the collection and coding of all data into a list of different codes that have been picked up from the data collected, the next step was to search for themes. This step guarantee that the procedure of assessing the generated labels for a more comprehensive meaning is adhered to. Additionally, throughout this process, unrelated labels were eliminated, and duplicate labels combined and given temporary themes with higher-level descriptions like maintenance, incentives, efficiency levels etc. The study looked at the linkages, repetition, and relevance of the original labels. The updated labels were incorporated into the main themes.

3.8.5.2 Reviewing and Defining of the Themes

The fourth phase is reviewing themes, the potential themes were further examined to see if they needed to be reworded, divided up, or completely discarded. The other themes were evaluated for fit for the objectives of this study. A relationship visualization and pattern between the themes, mind maps were used.

The fifth phase starts as soon as the researcher obtains a sufficient thematic map of the data shown in Table 4.1 for themes derived from participants responses to create and define the themes. The themes were operational technology, maintenance, incentive system, readiness to improve, operational efficiency levels etc. The researcher runs a final analysis to make sure the themes and connections are appropriate. At this point in the study, potential themes were once again reviewed for appropriateness, and the study's final themes were developed based on how frequently participants responded. Based how the themes respond to the study questions, a thorough analysis of the themes was constructed.

The last phase is starting to work on the analysis of extracted themes. It is generally expected that the researcher has already established a set of themes for connecting what the study found versus the existing TOS literature (Clarke & Braun, 2021). The researcher created a detailed narrative of themes related to the study goals, the body of literature, and the researcher's chosen research model for this dissertation. To analyse the themes, existing efficiency literature on TOS was used in the discussion.

The outlined six steps of qualitative data analysis were executed through NVivo computer software for data entry and transformation (Royse et al., 2015). This software tool was chosen because it is widely used and provides credible information for qualitative research. NVivo's focus is on qualitative data analysis that relies on coding as a main tactic that facilitates thinking, linking, writing, and modelling in ways that go beyond a simple reliance on coding (Jackson & Bazeley, 2019). Driven by process explained by Jackson and Bazeley (2019), the researcher in this study listened to the interview recordings more than once to get a clear understanding of the data so that themes could be identified. The data was categorised and coded into themes relating to the efficiency of TOS in handling cargo at Transnet Port of Durban. The themes were then reviewed and correlated as the findings of this study. The data were analysed to perform reliability and validity tests.

3.9 Summary

This chapter has provided a full explanation of the research design and philosophy that was used in this study to investigate Navis TOS in reaching the appropriate levels of efficiency at the Transnet Port of Durban. The researcher has also discussed theoretical approach and methodical choice, as well as research strategy outlining how to answer the research questions. The techniques used in data collection methods, inclusion and exclusion criteria are amongst the tools that guaranteed the study's validity was covered. To guarantee that each interviewee was available to participate in the research, the researcher scheduled appointments with each

participant well in advance. The participants were aware that they would be interviewed at a specific period of the study's data collection. Each research interview began with a brief explanation from the researcher about the study's goals and potential business benefits. The requirements of the participants in this study were explained to them and the researcher ensured that each participant understood. A brief explanation of ethical issues was also included because they were considered during the investigation. The results of the semi-structured interviews are reported in the following chapter.

CHAPTER FOUR – DATA ANALYSIS, RESULTS AND DISCUSION

4.1 INTRODUCTION

The chapter presents data analysis that provide insights of the collected data to solve a problem under consideration. Hervás-Peralta et al. (2019) posit that terminal operators rely on TOS to enable a port to optimally utilise its resources, workforce, and equipment, allocate tasks, and obtain information quickly which, allows for timeous and economical decision making. According to Nishimura (2020), being efficient plays a crucial role in giving the port an edge over its competitors, and the contributing factors of port efficiency are critical for its continued existence and dominance in the global trade network. This chapter is used to achieve the following objective:

4.1.1 To determine the impact of workload on operational efficiency of the Navis TOS at Transnet Port of Durban Terminal.

4.1.2 To determine utilization of the Navis TOS at Transnet Port of Durban Terminal in optimizing operational efficiency.

4.1.3 To determine the impact of throughput on the Navis TOS in improving operational efficiency at Transnet Port of Durban Terminal.

4.1.4 To establish the impact of actual use on operational efficiency of the Navis TOS in improving operational efficiency at Transnet Port of Durban Terminal.

4.1.5 To determine the usefulness of available technology in executing operational tasks to improve efficiency at Transnet Port of Durban

4.2 Analytical Techniques

Data analysis involves the knowledge of using analytical and logical thinking to analyse data to identify themes (Royse et al., 2015). Jackson and Bazeley (2019) refer to the five analytical research techniques that can be used in a qualitative approach as thematic analysis, content analysis, ethnography, grounded theory, and narrative inquiry. They postulate inductive and deductive methods can be used in thematic analysis.

The semi-structured interviews used in the qualitative analysis of this study followed a deductive content analysis approach that uses a six-step approach by Creswell (2019) to inform the design of the interview questions used to gather data from respondents. The deductive approach allowed the researcher to test the concepts illustrated in the research model in Figure 2.6 that was used for this study. This enabled the researcher to identify themes used in exploring the efficiency of the Navis terminal operating system at Transnet Port of Durban (Williams &

Moser, 2019). The findings were substantiated by making reference to what was quoted from the research participants, keeping in line with terminal operating system efficiency themes. The researcher converted the data from the participants into a written format using the recorded MS Teams interviews. The converted data was analysed and reviewed by the researcher to ensure that it was still credible, and the analysis did not give rise to any major amendments to the converted data.

4.3 Data Analysis

The themes developed from a collected data are aligned to the study objectives in chapter 1. Naidoo (2021) argues that to enhance the terminal efficiency at Transnet Port of Durban, all the available features of Navis TOS for equipment controlling and scheduling functions must be optimally utilized to promote a greater collaboration between the ICT, Operations and Technical departments. Through operating divisions collaboration, Transnet systems will work together more effectively, enhancing performance and streamlining the transfer of freight, including containers across divisions (Transnet Port Terminals, 2013a). The following section will discuss in detail the developing and analysing of themes that emerged in this study.

Table 4. 1: Themes Derived from Participants Responses linked to related Research Questions

Theme	**Research Question**	**Frequency**
Planning operational activities	What is the impact of workload on operational efficiency of the Navis TOS at the Transnet Port of Durban Terminal?	6
Challenges in business capabilities	What is the extent of Navis TOS utilization is optimizing operational efficiency at Transnet Port of Durban Terminal?	5
Readiness to improve	What is the relationship between the actual utilization of the Navis TOS and operational efficiency at Transnet Port of Durban Terminal?	3
Incentive system	What is the impact of throughput on the performance of the Navis TOS in improving operational efficiency at Transnet Port of Durban Terminal?	7

Theme	Research Question	Frequency
Skills transfer	How useful are the available technologies in executing operational tasks to improve efficiency at Transnet Port of Durban?	2
Maintenance strategy	What is the relationship between the actual utilization of the Navis TOS and operational efficiency at Transnet Port of Durban Terminal?	6
Preventive maintenance	What is the impact of throughput on the performance of the Navis TOS in improving operational efficiency at Transnet Port of Durban Terminal?	6
Corrective maintenance	What is the impact of workload on operational efficiency of the Navis TOS at the Transnet Port of Durban Terminal?	4
Critical maintenance issues for continuity	What is the extent of Navis TOS utilization is optimizing operational efficiency at Transnet Port of Durban Terminal?	4
Operational technology availability	What is the extent of Navis TOS utilization is optimizing operational efficiency at Transnet Port of Durban Terminal?	9
Operational technology maintenance	What is the impact of throughput on the performance of the Navis TOS in improving operational efficiency at Transnet Port of Durban Terminal?	9
Operational efficiency levels	How useful are the available technologies in executing operational tasks to improve efficiency at Transnet Port of Durban?	5

4.3.1 Developed Themes

The Transnet Port of Durban overall performance has been on the downward spiral for the last five years (Oguti, 2017), hence the study to explore the efficiency of the Navis terminal operating system. It is important to understand the challenges Transnet Port of Durban is facing, because it is the premier container port that handles roughly 60% of the country's cargo (Naidoo, 2021).

Nvivo software was used to analyse the semi-structured MS Teams interviews and helped to categorise the themes, which are shown in Figure 4.1 that highlights the study's important findings.

4.3.1.1 Planning Operational Activities

Planning operational activities plays a crucial role in optimizing the efficiency of Navis TOS at container terminal like the one for Port of Durban. Effective planning ensures that resources are allocated efficiently, tasks are executed seamlessly, and operational objectives are achieved in a timely manner. Several studies have investigated the relationship between planning operational activities and the efficiency of TOS at container terminals, providing valuable insights into best practices and strategies for enhancing operational performance.

One key aspect of planning operational activities is the allocation of resources, such as manpower, equipment, and berth space, to handle incoming and outgoing cargo efficiently. A study by Heilig et al. (2020) highlights the importance of dynamic resource allocation strategies in optimizing the performance of Navis TOS. By dynamically allocating resources based on real-time data and demand forecasts, terminals can minimize congestion, reduce waiting times, and improve overall efficiency.

Furthermore, effective planning of operational activities involves optimizing workflow processes and task sequencing to minimize bottlenecks and maximize throughput. Kizilay and Eliiyi (2021) emphasizes the significance of efficient task scheduling algorithms in improving the performance of Navis TOS. This results in optimizing task sequences and minimizing idle time between tasks, enabling terminals to streamline operations and enhance productivity.

4.3.1.2 Challenges in Business Capabilities

Business capabilities encompass various aspects such as organizational structure, human resources, technology infrastructure, and strategic management practices. Identifying and addressing these challenges is essential for optimizing Navis TOS efficiency and improving

terminal operations. The challenges faced by container terminals in developing and maintaining business capabilities, offering insights into potential solutions and strategies for improvement.

Transnet Port of Durban significant challenge in business capabilities is the alignment between organizational structure and operational objectives. Min et al. (2017) highlights the importance of organizational alignment in optimizing terminal performance. Inefficient organizational structures, such as siloed departments and unclear lines of communication, can hinder collaboration and coordination, leading to suboptimal TOS utilization and operational inefficiencies.

Human resource management practices play a critical role in determining the effectiveness of a container terminal. According to Gekara and Nguyen (2020), the challenges associated with workforce training and development in the maritime industry are core to port inefficiencies. Inadequate training programs and skill gaps among employees can impact Navis TOS usage and system performance. Effective human resource management practices, such as continuous training and skills development, are essential for ensuring that employees can effectively utilize Navis TOS functionalities and maximize operational efficiency.

4.3.1.3 Readiness to Improve

Readiness to improve efficiency of the Navis TOS at the Durban Container Terminal is dependent on various factors, like organizational goals, technology deployment, calibre of the gangs, and stakeholder commitment. Bichou (2021) asserts that container terminals full utilization of TOS is driven by organizational readiness to continuously achieve improved port efficiency. It is therefore a combination of factors such as leadership support, employee readiness, and organizational culture that plays a significant role in ensuring Transnet Port of Durban optimize Navis TOS.

Technological readiness is at the center of TOS optimization success. Spieth et al. (2021) postulate that technological infrastructure and system capabilities enable efficient TOS operations. The system reliability, scalability, and compatibility with existing infrastructure influence the readiness of a container terminal to leverage TOS functionalities effectively. Investing in robust technological solutions and ensuring that the necessary hardware, software, and network infrastructure are in place are essential for enhancing technological readiness and maximizing Navis TOS efficiency.

4.3.1.4 Incentive System

Motivating employees and driving efficiency at container terminal like the one for Port of Durban, particularly in relation to the utilization of the Navis TOS is paramount. Widyawati et al. (2021) state that aligning incentive systems with operational objectives and performance metrics drive efficiency gains at container terminals. Incentive systems that reward employees based on key performance indicators such as vessel turnaround time, berth productivity, and container throughput can incentivize behaviours that lead to improved TOS utilization and operational efficiency.

Min et al. (2017) explored the effectiveness of performance-based incentive systems in improving TOS efficiency and operational performance. Therefore, linking incentive rewards directly to Navis TOS related performance targets, Transnet Port of Durban can create a result driven culture that prioritizes efficiency and continuous improvement.

4.3.1.5 Maintenance Strategy

Maintenance strategy plays a crucial role in ensuring the reliability, availability, and efficiency of the Navis TOS at the Transnet Port of Durban Notteboom and Rodrigue (2023) contend that regular maintenance activities, such as software updates, hardware inspections, and system optimizations, are essential for identifying and addressing potential issues before they escalate into critical failures. Through the implementation of proactive maintenance strategies, Port of Durban can ensure that the Navis TOS remains operational and reliable, thus minimizing disruptions to terminal operations and enhancing overall efficiency.

Hervás-Peralta et al. (2019) argue that adopting cost-effective maintenance approaches, such as reliability-centered maintenance and asset management strategies, Transnet Port of Durban can minimize TOS maintenance costs while maximizing system reliability and efficiency. This allows terminals to achieve a lower total cost of ownership and realize greater returns on the investment of TOS technology. Notteboom and Rodrigue (2023) posit that maintenance strategy support TOS integration with other deployed technologies. It enables effective maintenance practices to ensure that the Navis TOS remains compatible with other systems, such as Navis Sparcs N4, General Cargo Operating System (GCOS), SAP Enterprise Resource Planning (ERP), EDI and CAMCO system, thereby facilitating seamless data exchange and workflow integration. This integration enhances operational efficiency and enables terminals to leverage the full capabilities of the TOS system effectively (Bichou, 2021).

4.3.1.6 Operational Technology Availability and Maintenance

Availability of critical operational technologies, such as network infrastructure, servers, and data storage systems, is essential for ensuring uninterrupted TOS operations (Min et al., 2017). Any disruptions in these technologies can negatively impact Navis TOS performance and overall Transnet Port of Durban efficiency.

According to Hervás-Peralta et al. (2019), operational technology availability and maintenance are crucial factors that influence optimizing TOS performance at container terminals. In the case of the Durban Container Terminal, effective maintenance strategies, such as preventive maintenance, predictive maintenance, and condition-based monitoring would assist in identifying and addressing potential issues that may affect Navis TOS availability and performance (Gekara & Nguyen, 2020). Therefore, implementing proactive maintenance practices can enable Transnet Port of Durban to minimize downtime, reduce system failures, and ensure that the Navis TOS remains operational and efficient.

Pelevic et al. (2022 May) postulate that the impact of technology integration of Navis Sparcs N4, GCOS, SAP ERP, EDI and CAMCO systems enhance interoperability of TOS, and which results to its efficiency by supporting seamless data exchange and workflow integration. This integration improves operational efficiency and would enable Transnet Port of Durban to leverage the full capabilities of the Navis TOS effectively. Furthermore, Pelevic et al. (2022 May) argue that regular technology upgrades, software updates, and hardware replacements are essential for ensuring that the Navis TOS remains up-to-date and aligned with evolving operational requirements. So, investing in technology lifecycle management practices, Transnet Port of Durban can extend the lifespan of Navis TOS, minimize obsolescence risks, and maintain optimal system performance and efficiency.

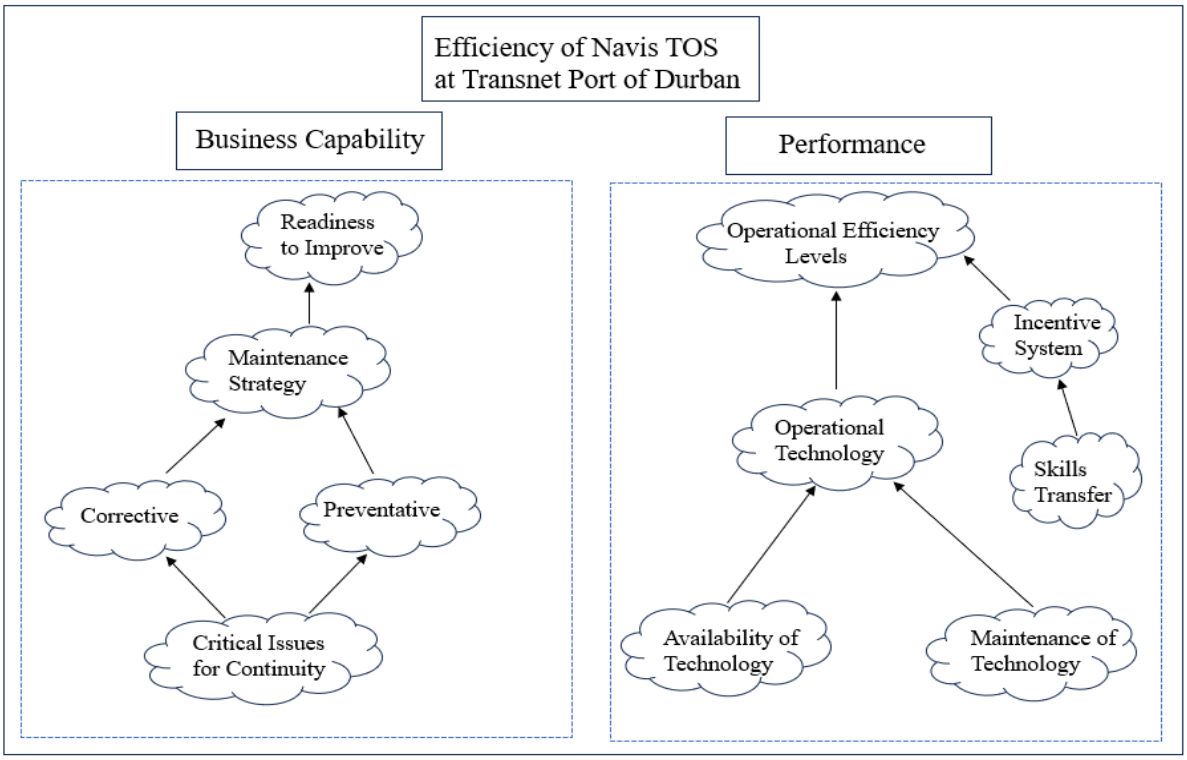

Figure 4. 1 Emerging Themes
Source: Authors Own Design

Deductive thematic analysis was utilized to conduct the qualitative analysis of this study, a research model is a foundation of research objectives to be addressed through research instrument. Saunders et al. (2019) postulate that starting the investigation with an analytical framework and connecting it to the body of knowledge currently in use, the researcher was able to use a deductive approach. In the case of Transnet Port of Durban, Navis TOS supports the streamlining of day-to-day tasks and developing better gate scheduling, equipment control, and ground stowage strategies (Stahlbock & Voß, 2008). The collected data is critical to address efficiency challenges at the port because the consequences are detrimental to the economic growth of South Africa, as neighbouring countries are capitalizing in a major port poor performance.

4.4 Business Capability

Planning of operational activities is an important task at the Transnet Port of Durban that is directly linked with the port capability to improve efficiency (Gekara & Nguyen, 2020). Terminal yard connects the waterside and the landside, hence good yard planning is crucial to the success of the whole port (Heilig et al., 2020). At Transnet Port Terminals, national planning from Head Office does high-level plan and then cascades a detailed planning to the port which is Transnet Port of Durban in this study. The technological product for planning and cargo handling management is Navis terminal operating system (Transnet Port Terminals,

2013a). The Table 4.2 illustrates the different planning types, measures, and targets that makes up a Transnet Port of Durban performance target in a nutshell.

Vrakas et al. (2021) state that ship planning plays a crucial role in ensuring the efficient movement of vessels through the Durban Container Terminal is within a target of 60 hours. Port of Durban aims to optimize its marine operations processes by minimizing turnaround times, maximize throughput, and enhance overall operational efficiency to remain attractive to shipping lines. The value-add of efficient ship planning at Transnet Port of Durban is inclusive feeder connections for transshipment cargo due to geographical strategic position of the port (Naidoo, 2021).

Marine operations activities involve coordinating various operational tasks and resources to facilitate the arrival, berthing, and departure of vessels. These activities may include berth scheduling, cargo handling planning, resource allocation, and communication with shipping lines, port authorities, and other stakeholders (Setiawan et al., 2018). Efficient berth scheduling is essential for minimizing vessel waiting times and utilizing berthing time target of 60 hours at Transnet Port of Durban. Optimizing berth allocation based on vessel arrival times, cargo volumes, and terminal capacity, the port can reduce congestion and streamline vessel movements, contributing to lower SWH. This drive towards handling 250 TEUs per hour supported by 32 GCH per shift if it is manned by skilled 14 gang members (Nishimura, 2020).

Effective yard planning ensures that resources, such as cranes, trucks, and gang members per shift are allocated efficiently for both landside and seaside to handle inbound and outbound cargo. According to Kaliszewski et al. (2020), coordinating cargo operations requires a great deal of collaborative communication by administrative, “planning”, team to facilitate ship schedules and berth availability for the Transnet Port of Durban. This assist to minimize idle time and maximize productivity by moving at least 60 containers per hour and turning around a truck in 40 minutes for every maximum hour of staging to access the port (Heilig & Voß, 2017). With these operational tasks aligning to a master plan, a “4 7 8” (4 straddles, 7 trains for inbound and 8 trains for outbound cargo) yard plan is executed for each ship-to-shore crane targeting 150 hauler moves per hour.

With Transnet Port of Durban proper allocation and management of resources, including equipment as well as manpower, seamless marine and terminal operations are practical. The management of Transnet Port of Durban must ensure that the right resources are available at the right time and place, for the port to minimize delays and bottlenecks, contributing to

improved SWH performance and meeting container terminal operations contract (Kaliszewski et al., 2020).

4.4.1 Planning of Operational Activities

Boer and Saanen (2014) concur that TOS is very important in terminal operations as it serves as the heart for supporting planners in executing quality shift plan in a short period of time. The function of the Transnet Port of Durban is to provide container storage during transit and facilitate the transition between modes within the supply chain and consequently, efficient processes in the port are fundamental (Lee & Kim, 2013). TOS are made to solve all the terminal operation needs for a port to be efficient and competitive. However, suboptimal terminal operations lead to efficiency constraints and has a significant implications for the whole supply chain including transportation costs, hence making quicker turnaround times is a critical factor in improving Port of Durban's competitiveness (Kammoun, 2018). Transnet Port of Durban knows the capabilities of the Navis TOS and requires some customization to synergize its standard operating procedures for a desired operational efficiency. The Port of Durban has avoided heavy customization which generates not only escapable costs during development, but also increase support costs and future cost for upgrades and system development (Transnet Port Terminals, 2013b).

Table 4. 2: Performance Targets

Plan	**Measure**	**Target**
Ship (Vessel) Planning	Turn Around Time or Ship Working Hours (SWH)	60 Hours
Terminal Planning	Twenty-Foot Equivalent Units (TEUs) per hour	250 Units
	Twenty-Foot Equivalent Units (TEUs) per financial year	2 Million units
Crane Planning	Gross Crane Moves per hour (GCH)	32 GCH
Berth Planning	Berthing Time	60 Hours
Shift Planning	Gang (Labour) per Shift	14 Members
Yard Planning	Number of Boxes per hour	60 Boxes
	Truck Turn Around time	40 Minutes
	Staging time	60 Minutes
	Number of Trains	7 For Imports and 8 For Exports
Straddles Planning	Number of Straddles per Crane	4
Hauler	Moves per hour	150

Poor communication and reporting between customers and staff are at the center of erratic planning at the Transnet Port of Durban. Robinson (2002) contends that it is imperative to consider the terminal characteristics when setting performance targets for the ports. Participants of the study concurred that vessel planning is dependent on various factors such as the yard planning strategy of ensuring that export boxes are closer to the vessel, import boxes are closer to the landside intermodal transition zone (Boer and Saanen, 2014). This strategy improves the vessel turnaround time and the berthing time at the Transnet Port of Durban. It is however dependant on TNPA to reduce the amount of time lost in vessel movement during vessel crossovers. Several vessels calling at the Transnet Port of Durban are bigger in size compared to vessels docked in the past, and sometimes three tugs are required to bring those vessels across (Prokopowicz & Berg-Andreassen, 2016). The issue of extended berthing time emanates from breakage of loading and discharging equipment, gang member shortage, the available terminal yard, and the inadequate berth capacity at the Transnet Port of Durban (Cahyadi & Sugiyono, 2021).

> *"Vessel planning depends on the ship size, cargo volumes that it carries and the berthing area (to be) allocated and also the number of vessels expected to be worked in the port." P5*

4.4.2 Maximize the Use of Navis TOS

Cahyadi and Sugiyono (2021) assert that equipment availability and reliability are critical, especially the cranes at the seaside, which is the Transnet Port of Durban cash cow, to improve turnaround time on the vessel. Ideally, the equipment must sustain a period of eight hours without breaking down. Improving the overall performance and efficiency of a port handling the import, export, and transshipment of containers depends on the efficient deployment of equipment in container terminal (Schwientek et al., 2020). The Transnet Port of Durban employees need to fully utilize the Navis TOS to leverage on job sequence of the deployed work instruction in the system to able to keep up with the pace of required moves per hour for equipment to achieve set target. The Transnet Operating Divisions (ODs) perform various functions, with TFR managing the rail network, TNPA managing the port waters and TPT managing the container terminals at the Port of Durban (Setiawan et al., 2018). Inadequate use of Navis TOS and gate processes results in fragmented yard operations in one port. Hence, study participants advocate that all these functions should be on the same platform of the Navis TOS to coordinate rail, marine services, vessel discharging and loading timeously and improve the communication of berth planning.

> *"ODs must work on the same system to resolve rail, terminal and vessel challenges and improve communication of integrating activities like berthing plans." P7*

4.5 Supporting Business Capability

Transnet Port Terminals (2013b) states that a Transnet Port of Durban target of 32 gross crane moves per hour is well known by both management and gang members. This target is an hourly measure that assist in ensuring ship working hours remain at 60 provided all required resources are available. The workload between shifts is allocated equally in all three shifts and the activities are based on how many vessels are waiting at the outer anchorage of Port of Durban or on the berth (Transnet Port Terminals, 2013b). The workload for imports in Figure 4.2 is planned jobs that are dependent on operational tasks or activities for a particular shift displaying how management with planning team keep a good balance across all three shifts. Most of the tasks in a shift involves unloading and loading of the ship cargo, moving the cargo to and from the landside areas for further logistical process like terminal yard space creation, road, and rail transportation (Carlo et al., 2014b). The participants consider discharging as much simpler task than loading a vessel such that when discharging a vessel more moves is discharged per hour. But when loading, a reduced moves can be loaded per hour.

> *"The calculation of cargo volumes planned for a particular shift talks to the vessel stowage (the secure packing of cargo onboard a ship) that determines how much of the cargo to offload and or load and we then calculate the vessel stay across the shifts that we are working, which is linked to the vessel stay in the terminal." P4*

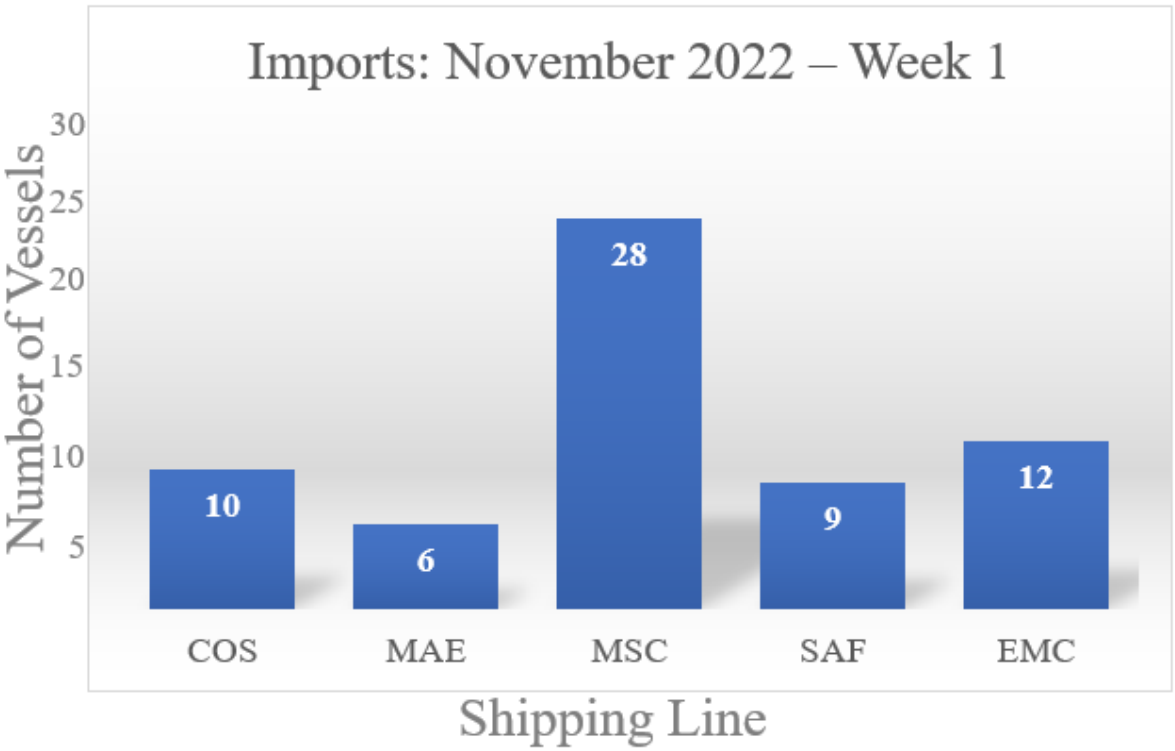

Figure 4. 2: Shift Tasks (Import Workload)

There is a general misalignment between the capabilities at Transnet Port of Durban disposal and the performance targets set for the financial year (Transnet Port Terminals, 2013b). The

available capabilities deployed through technology is not complemented by equipment and human resources, over and above this, there are some elements of working in silos which is hampering Transnet Port of Durban potential to achieve higher performance levels. During the study, it was evident that TPT has the potential to improve the performance levels in the Port of Durban with equipment and human resources challenges adequately addressed.

4.5.1 Execution of Tasks

For the tasks to be efficiently executed in a shift, the following resources are required: (a) Straddle Carriers to transport containers from the stack to the vessel and vice versa, (b) Straddle Carrier drivers to operate straddles when bringing containers from the stack to the vessel and vice versa, (c) Planners to efficiently use the planning system and issue shortest distances to the equipment, (d) Cargo coordinators to coordinate yard operations and record everything that happens under the crane, which might be delays, hatch covers opening and closing, damages on the cargo and (e) Quay Cranes and Quay Crane drivers for loading and or discharging the vessel. Participants sharply raised that the yard planning must be 100% correct for the shift tasks to be completed within ship working hours.

> *"The vessel must be closest to the seaside and cranes closest to the berth where the vessel is docked. A minimum of two straddles services a vessel depending on the vessel size, but four straddles are adequate for big vessels. Otherwise, the operations are slowed down from the stack area. We always advice yard planners to plan containers in different rows to accommodate maximum number of straddles for their movement." P1*

Figure 4. 3: Shift Tasks (Export Workload)

The congestion of exports is not alarming due to the Transnet Port of Durban operating model. The shift operational tasks workload in Figure 4.3 demonstrates the preference of gang members in terms working the vessel. It is therefore important for operations managers to strike a balance on rostering gang members to eliminate adverse execution of tasks at the Transnet Port of Durban

4.5.2 Upskilling TOS Users

Transnet Port of Durban is faced with a serious skills gap required for a deployed operational technology. The Transnet Academy Maritime School of Excellence is a mandated centre to provide training for TNPA and TPT, however the Maritime School of Excellence does not have expert coaches or trainers to produce skilled system users. Transnet Academy need to be empowered through collaborations or partnerships with subject matter experts of operational technology to impart the required skills and knowledge to produce competent system users.

4.5.3 Preventative Maintenance

The push to achieve targets leads to a reluctance for equipment release when it is due for a preventive maintenance. The consequences are calamitous in the long term, and compromises performance of the equipment. A compromised equipment ends up with breakdowns that could have been avoided thus requiring corrective maintenance that result to insufficient resources for operations (Zhang et al., 2020). Corrective maintenance generally takes longer as compared to preventive maintenance. The equipment is generally operated 24/7 throughout the year, except three public holidays dedicated to maintenance at the Transnet Port of Durban.

The equipment maintenance at the Transnet Port of Durban is a very important process because it impacts operational efficiency. However, there is a problem of long maintenance cycles, at the same time, the weak technical workforce which exacerbate equipment reliability problem at the port. The performance targets are prioritized, as a result the port sacrifice the equipment maintenance with long term benefits for short term gains of achieving shift targets (Schwientek et al., 2020). This has been going on for years and the results are showing now with the quantity of equipment available for operations keeps on dwindling. A greater number of equipment spend more time in maintenance than in port operations (Zhang et al., 2020). This means technicians and engineers are fully engaged with attending equipment breakdowns and corrective maintenance, leaving a gap on the equipment preventive maintenance. The technicians and engineers are already in short supply, not to mention the ones with the critical skills and experience that Transnet Port of Durban need for the aged equipment. So, the

problems keep on spiralling as the lack resources results in less reliable equipment available for Operations to complete operational tasks in line with contracted SWH.

4.6 Technological Infrastructure

The available operational technologies at Transnet Port of Durban are capable to enhance operational performance with the integration of Navis Sparcs N4, General Cargo Operating System (GCOS), SAP ERP, EDI and CAMCO system (Vrakas et al., 2021).

4.6.1 Operational Technology

Wasted time is associated with truck booking system points, yet the gate processes are streamlined through automatic scanning of trucks as they arrive at the Transnet Port of Durban. The SAP ERP system incorporate all other business departments to support commercial activities, such as finance, materials management, and customer relationship management at the container terminal for a smooth port operation. However, these operational technologies are available over 95% of the time to contribute to the overall throughput, safety, and performance of the container terminal. This is because one technology is good as its weakest link in the chain of technologies used at Transnet Port of Durban.

> *"We have established an ongoing training, awareness campaigns and road shows for the available technologies that used in the terminal. These are part of management commitment to empower our people, be it a new upgrade or ordinary training, employees must continuously improve to produce desirable efficiencies for our port." P1*

Heilig and Voß (2017) agree that technology has become a key component of transferring and processing massive amounts of data in global logistics chain. The available technology plays a huge role in operations efficiency at the Transnet Port of Durban, even though there is still a room for improvement. Operational technology offers seamless transmission of work instructions and coordination of activities for smooth execution of operational tasks (Vrakas et al., 2021). Navis TOS is the market leader (Heilig & Voß, 2017). It has capabilities that would significantly improve Transnet Port of Durban operational efficiencies, however TOS utilization of Expert Decking, PrimeRoute, Rail Autostow and Vessel Autostow modules capabilities are not explored due to training related issues. The skilling of Transnet Port of Durban employees is critical for Transnet to realize the return on investment for the TOS.

> *"Autostow add-on can allow us to create an entire sequence for a vessel within two or three minutes instead of the manual way of planning 3000 to 4000 containers and wasted time affects productivity levels." P5*

"The technology is more than sufficient. It is 100% sufficient. It can be used better, but it is definitely the right system for Transnet Port of Durban." P1

4.6.2 Skills within the Port

The TOS has capabilities, however most of the modules offered on the system package are either not activated or the current pool of system users are not well versed with these modules and sometimes referred to as enhancements, yet they are not (Transnet Port Terminals, 2013a). The in-house training programs by Transnet Maritime School of Excellence does help to a certain extent but lacks system master personnel to transfer the Navis critical knowledge. TPT has brought overseas experts investing huge amounts on national planning centre staff training, but long-term benefits are yet to be seen (Transnet Port Terminals, 2013b). Operational technology is crucial to sustain economic growth and competitiveness of the port, as deployed technology enables the Transnet Port of Durban to get better efficiency levels.

TPTs top management need to understand that deploying Navis TOS which is dubbed as the best port operations system in the world, their ports would not instantly be most efficient without complementary operational resources. Poor crane productivity and vessel turnaround time is connected to a calibre of gang member manning various workstations at the port. Any system is generally garbage in garbage out (GIGO) and the quality of output information is directly related to the input data (Vrakas et al., 2021). The Transnet Port of Durban management need to note that without knowledgeable system users in all areas of port operations, Navis TOS will seem like an ordinary system. According to Transnet Port Terminals (2013a) the operating division yet to realize full return of Navis TOS investment because investing in staff is just as important as investing in equipment and software systems.

The overarching operational technology maintenance plans for the Transnet Port of Durban strategically coincides with three main public holidays (New Year's, Workers', and Christmas day) on national calendar, that generally sees low cargo volumes at the port. Any other emergency system maintenance tasks are dealt with as and when opportune moments arise during shift changes, and the system support team keeps it at a maximum of 30 minutes. The operating system related delays in the operations were said to be due system misuse, cyber-attacks, and network glitches amongst other things.

"The civil unrests like the one in July 2021 last year resulted in a looting spree, cyber-attacks in 2021 caused chaos in container handling operations. The system integrity was compromised by ransomware attack, these disruptions caused serious impediment on our operational performance. We are continuously working hard to ensure that our

systems, especially Navis, are always robust and all the software and systems fully up to date." P10

4.7 Port Efficiency

As the country's largest port, Transnet Port of Durban requires best practices in cargo handling equipment dispatch, yard stacking, crane scheduling, and storage planning. In execution of operational tasks, pooling and routing straddles over multiple cranes will result to an improved yard equipment utilisation rather than deploying each straddle to a single and specific crane (Schwientek et al., 2020). Automation of yard stacking control is essential to improve yard capacity and greatly reduce container re-allocation when compared to manual stack planning. In comparison to manual vessel planning, automated stowage planning is critical for increasing productivity. With sufficient resources, crane allocation may be optimized to boost crane and gang output and improve vessel turnaround time over manual planning and communication at the port (Schwientek et al., 2020).

4.7.1 Use of Available Technology

The growing significance of Transnet Port of Durban in global trade needs an extraordinary effort by the Transnet to improve its operations and tasks. Suboptimal strategies have a direct effect on key operational performance measures (Jungen et al., 2021). Hence, the use of available technology (Navis TOS, GCOS, SAP ERP, EDI and CAMCO system) and effective terminal operating model that suit straddle-carrier, rail mounted gantry cranes, handheld computer and vehicle mounted computer terminal equipment. The Navis TOS was deployed to boost terminal operations because the yard operation is the most complex part of a terminal as it oversees both incoming and outgoing container transportation simultaneously (Transnet Port Terminals, 2013a). The terminal productivity is greatly determined by resource allocation and planning in the yard through TOS. The quay crane operation in which loading a container from a truck to a vessel or unloading a container from a vessel to a truck equates to a minimum 32 gross moves per hour. The coordination of yard operation at minimum gross crane moves per hour meets the container terminal operations contract of 2.5 days dwell time for a vessel at the port (Transnet Port Terminals, 2013b). Indeed, the provision of suitable infrastructure is crucial for the efficient processing of cargo. It also helps to prevent traffic jams, promote business growth, and ensure deep-sea container connectivity for sectors that rely significantly on international trade.

Nishimura (2020) argue that the smooth running of loading operations in a container terminal yard depends on the loading system of export containers. While Heilig and Voß (2017) posit

that an optimal Navis TOS routing algorithm for a straddle carrier executes the loading export containers in the port. This assists in reducing the total container handling time, which includes setup time from a specific slot in the yard and the travel time in between slots in a terminal yard. As shown in Figure 4.4 (Appendix G), calling a particular container in the yard, short notice decisions must be made in the TOS to pick a specific container and in which sequence, routing and hauling operations must be flexible (Schwientek et al., 2020).

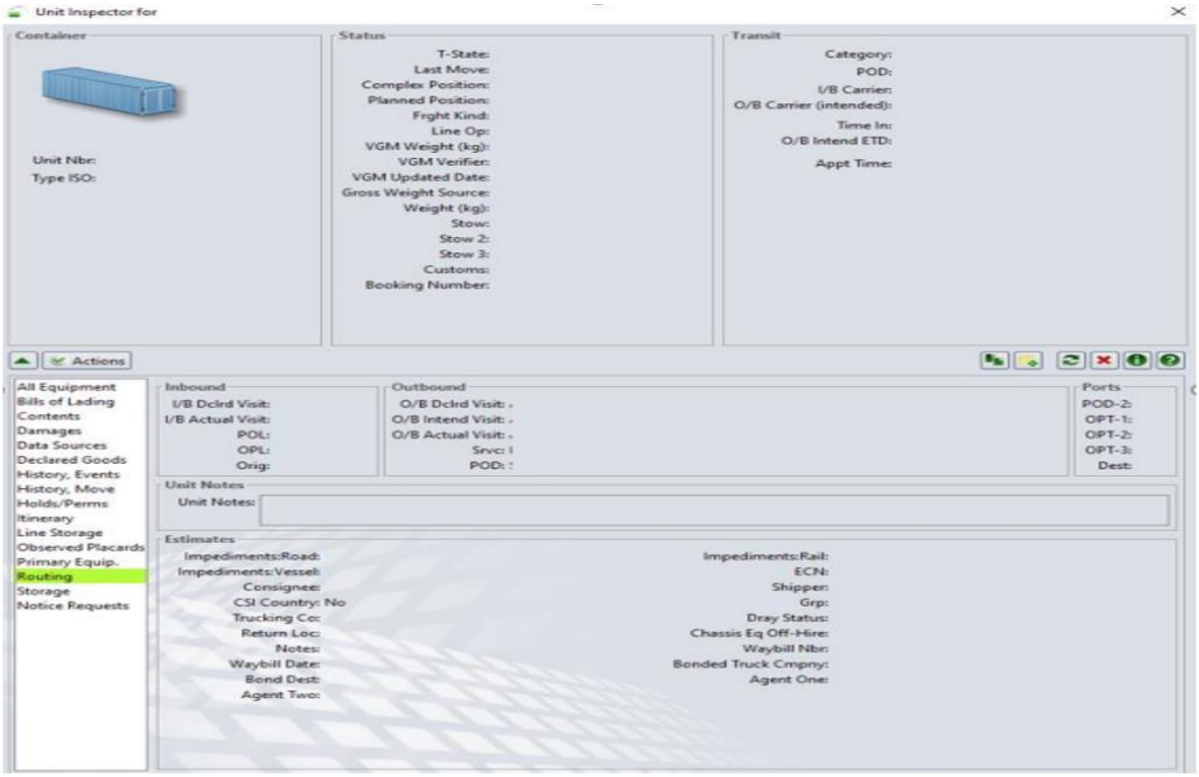

Figure 4. 4: Container Routing

4.7.2 Berth Planning

The available berths must be ready to dock vessel at outer anchorage and berth planning to be implemented effectively. The processing time of vessels can be minimised by having adequate equipment and human resources. The operations are based on a shift system, and the port operates 24 hours a day with three shifts of eight hours each. The three shifts start at 06h00 in the morning to 14h00, 14h00 to 22h00 at night, and the last shift start at 22h00 to 06h00 and the shift cycle goes on like that. The resources (gang, equipment, and the system) on a shift are planned and deployed based on the available berths, workload, and the number of vessels or ships at Port of Durban outer anchorage waiting for their slot inside the port. The optimal berth allocations to incoming vessels in an anchorage area is dependent on available resources for the shift to maximize yard utilization and minimize the dwell time for vessels at the port (Gekara & Nguyen, 2020).

"There is a shortage of resources, both equipment and human resources. We are currently operating at almost 80% of the desired capacity." P2

4.7.3 Planned Maintenance

Preventive maintenance means performing maintenance on equipment or parts of equipment before breakdown occurs. Preventive maintenance is founded on the principle of regular equipment check-ups on scheduled intervals either on a weekly, monthly, yearly basis or depending on the effect of use (Zhang et al., 2020). The check-up frequency period is recommended by an original equipment manufacturer to the technical team based on a number of hours or kilometres clocked by the equipment. The preventive maintenance of equipment is manageable, however the shortage of equipment at TPT makes it difficult to adhere to a planned maintenance schedule. The understanding at the Transnet Port of Durban is that preventative maintenance needs to be improved to ensure equipment availability and reliability.

"Preventive Maintenance is manageable and governed by our own statutory requirements and compliance structure. Our dedicated teams maintain the equipment fleet at specified intervals agreed upon at terminal planning and operations imbizos, and regular inspections are carried out to avoid damages before the planned maintenance." P9

"Equipment availability is too low to have an effective preventative maintenance plan and that is why we sometimes defer more complex maintenance tasks until a more opportune time. That obviously leads to a lack of reliability with the equipment. Other factors include unavailability of spares or obsolete parts from aged equipment. We rely on original equipment manufacturer to remanufacture obsolete components because they are not available off-the-shelf, and that adversely impacts preventative maintenance plan especially for aged equipment." P2

At Transnet Port of Durban, the efficiency of operational technology and its maintenance falls within the responsibility of the ICT department, whose key tasks include scheduling maintenance of systems, servers, data centres, and applications (Transnet Port Terminals, 2013b). The Transnet Port of Durban system upgrades are scheduled for every two years, with regular patches as specified by the original equipment manufacturer in partnership with certified vendors supported by Transnet ICT department. This is one of the port management initiatives to enable high efficiency levels at the port.

4.8 Port Performance

Shipping companies choose ports and container terminals based on their location, port costs or fees, processing time, and trade routes (Ports Regulator of South Africa, 2015). Performance of ports is impacted by a number of factors in a competitive economy, these factors include

organizational and physical capability, quay equipment, integration within logistics networks, storage yard and local market features (Gekara & Nguyen, 2020). Nishimura (2020) affirms that the quay crane reliability is of crucial importance to ports and concerning terminal operation equipment, preventative maintenance regimes and remote diagnostic enhance equipment reliability.

> *"Performance management systems must support us and improve productivity. Management must design a favourable shift system to us because the current system is not working for us. We finish the cycle dragging ourselves." P2*

4.8.1 Visibility and Monitoring

Stahlbock and Voß (2008) asserts that it is essential that gang members understand how the system functions and can navigate its numerous functionalities and restrictions. Gang members can learn this expertise by going through training and constantly utilize acquired skills in live operations. The Navis TOS training must be prioritized to unlock system competency gaps at Transnet Port of Durban (Transnet Port Terminals, 2013a). The size of container vessels calling at the Transnet Port of Durban have grown, and the pressure is on for the terminal to ensure a quick vessel turnaround time (Heilig & Voß, 2017). The high value assets shipped by container vessels does not generate any financial benefit for investors if the vessel is at the outer anchorage waiting to be docked due skill shortage or unavailability of equipment at the terminal.

There has been a lack of personal development because the focus has been directed chasing and achieving targets. The consequence has been lacking operational visibility and monitoring. By providing appropriate training for crane operators and increasing crane intensity, it is possible to enhance the effectiveness of landside crane operations and facilitate efficient planning at Transnet Port of Durban (Hervás-Peralta et al., 2019). There are various challenges in executing port operations tasks like achieving 32 GCH stipulated in Table 4.2 due to the lack of skilled human resources and deficiencies in equipment. The human resources are inadequate at Transnet Port of Durban and at times, some shifts run without the required skill set and experience in completing the operational tasks. Berth planning is not at desired level and communication of work instructions from the system to Operations team is not properly done. If berth planners do not include five percent contingency plan for the alternative solutions if unforeseen event occurs, for instance an equipment breakdown, it causes challenges in operations (Min et al., 2017). A vessel may not arrive or arrive outside of the scheduled time forcing other vessels to wait at the outer anchorage as their berthing slots gets reallocated.

4.8.2 Vessel Turnaround Time

It is important to generate a robust berth plan at a container terminal level to ensure that Navis Sparcs N4 Planners execute efficient cargo operations (Nishimura, 2020). The study participants agree that challenges of berth planning are a result of centralized planning at the head office. The practice of not allowing a port to coordinate all the necessary activities and the supporting requirements like equipment, the planned maintenance, marine services for effective and efficient berth planning is part of non-accountability at operations level. Therefore, this planning process has no accountability as head office make decisions for the port to executes the pre-approved plan by national planning team.

> *There is a lack of equipment. On some days equipment is available but no adequate human resources to operate the equipment or vice versa. The equipment and human resources must be planned interdependently. Sometimes a vessel arrives outside their scheduled time and then the reallocation resources become difficult here because of the centralized planning process by HQ. P3*

Increasing the efficiency and quality of the working personnel is extremely important for Transnet Port of Durban to stay competitive and achieve port targets (Diakomihalis et al., 2021). Some equipment operators either arrive late or absent due to various reasons affecting the shift starting time and overall performance. Late arrivals are mostly due to traffic congestion on the Bayhead Road that leading to the port. The situation was worsened by the 2022 floods in KZN leaving the road badly damaged, such that traffic to the port was diverted through Bluff residential road (Transnet, 2022). There is a shift change over time of approximately 10 to 15 minutes reserved for daily meetings like ‘Indabas’ or ‘Green area talks’ to do hand-over of incomplete tasks, planned tasks for coming shift. The other pre shift activities that precede the actual execution of shift activities are also discussed because with no proper shift hand-over, employees working on a terminal yard sometimes get confused on how to proceed with the incomplete tasks from the previous shift.

4.8.3 Crane Productivity

The cause of decreased quality, workflow disruptions, low morale, and overall dissatisfaction that result in a large decline in efficiency levels at Transnet Port of Durban is gang member absenteeism. The shift absenteeism challenge is attributed to the current shift pattern. The study participants indicated that with three shifts of eight hours each over three weeks and two shifts of 12 hours (overtime shifts) on Saturdays or Sunday, get employees fatigued as they only get a full weekend to rest after 19 days of hard labour. ICT devices were also mentioned by study participants as the cause of delays for completing operational tasks sometimes, especially

HHTs (handheld terminals) not working properly or entirely causes delays in the shift, while waiting ICT technicians to resolve the issues.

> *"Containers left on the seaside confuses some operators to whether take them back to stack or to restore on-board the vessel. No visibility from system point of view, some operators lack skills to read work instructions. Manual hand over that does not always take place is heavily relied on when it comes to the vessel planning or yard planning; the planning strategies differ from one shift to another shift based on the skills. There is no uniformity of strategy, because some operators have their own ways of working on the system." P6*

Operational efficiency is hampered by conventional operations where each straddle carrier is assigned to a single quay crane and dispatched sequentially according to a generated move sequence by cargo coordinator, moving from one direction and returning empty in the other side (Vrakas et al., 2021). The conventional style of yard planning by some Yard Planners is extremely time consuming, costly, and unreliable. This makes it difficult for the Transnet Port of Durban to increase yard capacity and optimize terminal operations because of the inconsistent planning. Human error and planning discrepancies are inherent in vessel plans that are traditionally performed manually by people possessing different skills (Lee & Kim, 2013). Information sources sometimes disregard the operating environment and terminal restrictions, which are the bottlenecks at Transnet Port of Durban.

4.9 Supporting Port Performance

Transnet Port of Durban staff competency levels on the available technologies to execute operational tasks influences the actual tasks completed at terminal operations for both seaside and landside. The technological innovations are desired to increase yard volume and expedite cargo handling time, however the planning and management of terminal operations dependent on a skilled gang member (Lee & Kim, 2013).

According to Transnet Port Terminals (2013a) National Berth Planning determines and coordinates Port of Durban operations contract for berthing windows. These contract for berthing windows guarantees a departure time for calling vessel depending on a vessel arriving on time and does not go beyond the number of planned moves (Prokopowicz & Berg-Andreassen, 2016). Transnet Port of Durban runs on a fixed berthing window strategy, shown in Figure 4.5 (Appendix H) for berth allocation in a quay, which are agreed on once a year with main shipping lines. Berth availability is restricted outside of this arrangement, and unscheduled vessel calls may result in a three to seven days delay. Planning activities are completed in a top-down approach which does not factor-in deficiencies in resource availability

at the execution of operational tasks (Nishimura (2020). In the main, the National Berth Planning team is seized with ideal plan to execute operational tasks, yet equipment unreliability and skills shortage are challenges faced by supervisors in almost every shift at the Transnet Port of Durban. Due to top-down approach in planning activities, gang resort to improvisation methods of working with available resource to achieve the set targets regardless of whether targets are realistic. Hence, the study explored the usefulness of available technology in executing operational tasks at Transnet Port of Durban.

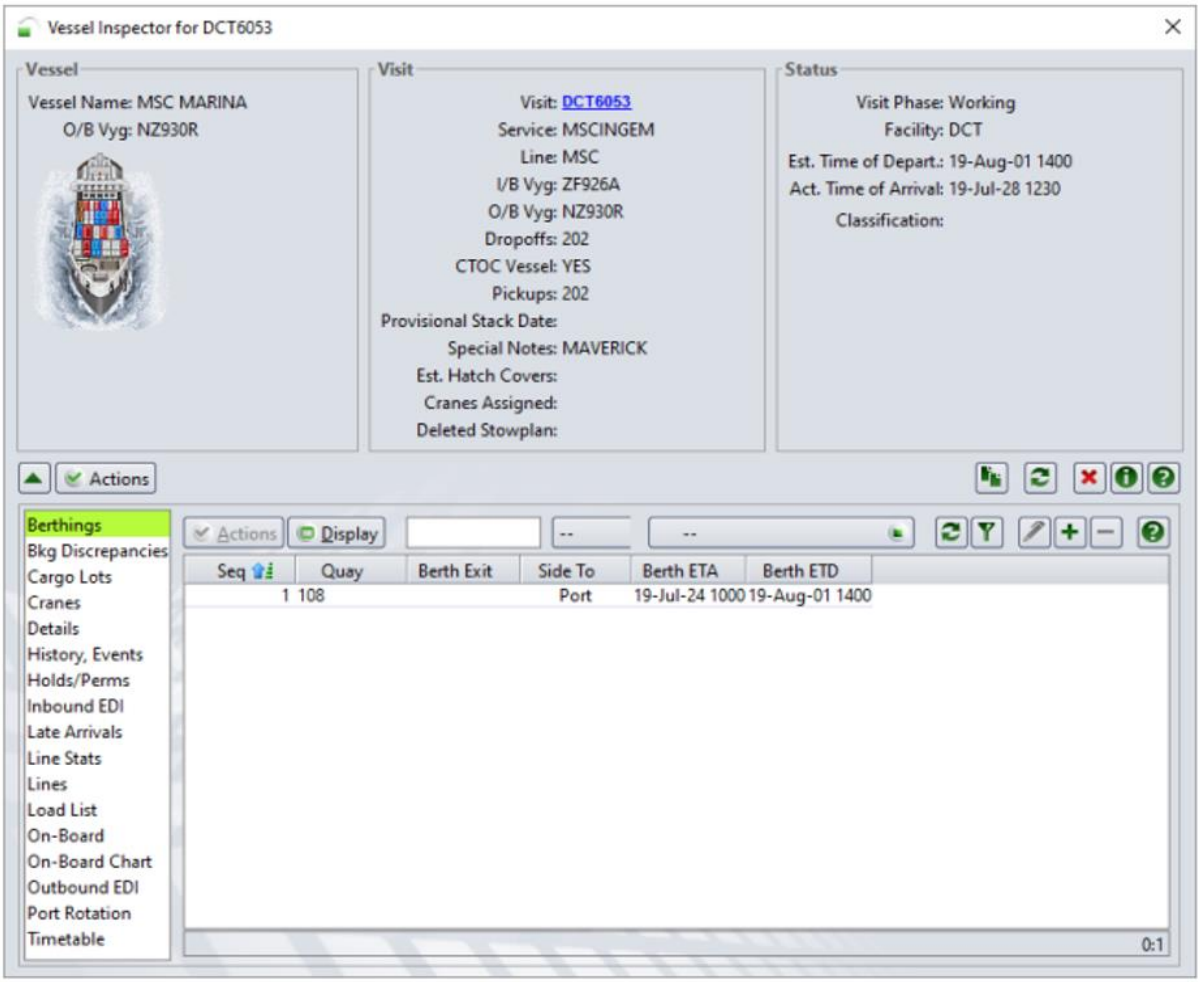

Figure 4. 5: Berth Allocation in a Quay

4.9.1 Experienced Gang

Gang members in a shift need to arrive early to prepare for a shift change and handover to enable seamless transition from one shift to the other. The use of hot-seat strategy during change overs of two-hours on or off swaps for the operators of overhead lifting equipment is ideal to maintain productivity tempo.

> "*Being an hour early helps to avoid delays of getting to the terminal late and clocking procedures. The access to the terminal is a serious problem for us, especially if there*

is a backlog at the terminal. The trucks jam all the lanes on Bayhead Road and accessing the terminal becomes impossible." P2

To guarantee efficient terminal operations and a consistent performance level from the gang, a fit for purpose training and coaching skills programmes must be earnestly implemented through the Maritime School of Excellence (Transnet Port Terminals, 2013b). A multi-skilled workforce will enable job rotation viable and beneficial for both TPT and gang members should operational demand arise. Technological products are just as effective as the people that can utilize it effectively, hence skilful gang are key to the Transnet Port of Durban efficiency. A detailed and task-oriented training programs like silver fox at TPT is one strategy to prevent a scarcity of these important human resource in situations when experienced gang are not readily available.

"Critical human resource skills are currently in short supply, and this limit our capacity to ensure a quick vessel turnaround time. This is due to several reasons, like a situation where personnel trained to an expert level leaves Transnet for better opportunities outside the country. The continuous need to fill the gaps and train gang members emanates from skilled personnel emigrating." P8

The operational performance of the different shifts is tracked at every hour and summarized on weekly basis, and it varies based on the shifts categories as some shifts are under resourced like shift 22h00 to 06h00. Shifts 06h00 to 14h00 and 14h00 to 22h00 were said to be performing at 26 GCH (gross crane moves per hour) while shift 10pm to 6pm lagged behind with 21 GCH, though figures varied from week to week. All the three shifts were not consistently achieving their targets with the average performance sitting at 80% of the targets (Transnet Port Terminals, 2013c). The shift system is designed to accommodate extra daily tasks and study participants in management positions felt the reigning shift system allows shift teams to perform their tasks.

"We prefer the 6 to 2 shift because we do not work overnight, and the morale is high in the morning. Knocking off at 2 affords us time to spend with our families and we also get to taste work-life balance at Transnet, you know." P6

"I prefer the 2 to 10 shift because for some reason we are more productive, even the Supervisors keep asking us why productivity drops on other shift. We do not know for sure, but maybe it is because we get good at night and relax a bit in the morning before we come to work at 2." P3

4.9.2 Fleet Management

Naidoo (2021) states that corrective maintenance is unplanned yet unavoidable, because Transnet Port of Durban does not have enough equipment to optimally operate the container terminal, hence deploying aged equipment to operations. The supply chain management

department plays a critical role of sourcing required components for the technical (workshop) team to carry out fleet maintenance. The pool of aged equipment is dependent on corrective maintenance to execute operational tasks during shifts. The equipment breakdown occurs unexpectedly, and it breaks the momentum of gang affecting GCH and SWH.

> *"The Buyers are responsible for buying spares we require for maintenance. If the required spares loaded in the SAP are not in stock for preventive maintenance as scheduled, the equipment is forced to keep on running till it breaks down. When we have sufficient spares of Kalmar available in the stores, Terex or ZPMC stock is insufficient or vice versa. We end up deferring certain plans or take other equipment that have spares in stock. The availability of spare parts is a big problem here. Hence, we are often in a crisis mode doing corrective maintenance. The Buyers with their processes and policies delays us big time, if spare parts can be available timeously, a lot of maintenance can be done and better managed as well." P3*

For container terminal fleet, TPT designed a tactical operational activity to manage freight transport services with the goals of cost reduction, customer satisfaction, and fleet optimization (Kim & Lee, 2014). The fleet management is responsible for the care of an asset equipment needs and equally so, the operations management is responsible for an appropriate use of the equipment. The two management teams must collaborate and design a continuous maintenance development at the strategic level. The objective of these collaborations is to drive business strategy of keeping the Transnet Port of Durban efficient and manage the reliability of resources deployed in operations. Furthermore, management teams must identify potential equipment failures and use original equipment manufacturers endorsed maintenance strategies to address them. This will ensure that an equipment useful life is maintained if not prolonged. A better equipment reliability and its usefulness is derived from an adequate maintenance strategy that impacts the overall quality (Zhang et al., 2020). Data collection is critical for an accurate equipment diagnosis as it enables seamless maintenance of the equipment.

> *"The strategy is to make sure that when equipment is scheduled for maintenance it must be done as per schedule of the plan to avoid breakdowns." P9*

The fleet of equipment being utilized as well as the available workforce at the Transnet Port of Durban must be taken into consideration when choosing and implementing a maintenance strategy. TPT need to consider all their internal and external operational aspects when designing a maintenance strategy for the container terminal to enable it to have reliable equipment. The ideal maintenance strategy at the Transnet Port of Durban should incorporate data collection capability, planning and maintenance schedule on the deployed technological product, supported by a dedicated original equipment manufacturer training programme

(Zhang et al., 2020). Once the equipment is on yard, it is presumed to be reliable and therefore it should sustain operations for the duration of 8 or 12 hours shift without breakdowns.

> *"By having more stock of spare parts available in our stores, the team can be more efficient when attending to breakdowns or basic maintenance of equipment. With a support from Procurement, Stores can carry enough stock at all times to enable the technical team to turnaround the fleet of equipment at our workshop for repairs or scheduled maintenance to be kept at agreed service level agreement with operations." P10*

4.9.3 Incentives

The operators for overhead lifting equipment have low morale due to what they perceive as unfair treatment and slave driving mentality from the Port of Durban management. The issue of incentive scheme is the main bone of contention as it affects their livelihood and that of their families, as they put it. Operators also find working environment not conducive as they battle with unreliable equipment across shifts, yet top management set performance targets that are impossible to achieve under the current circumstances where critical resources (equipment and gang) for a port operational productivity are limited. The operational efficiency is dependent on gang performances and can be easily put in jeopardy under the guise of these grievances. It is important to acknowledge the uniqueness of employees and consider that when designing the incentive system. Gang members have a particular preference that will entice, retain, and encourage a high performing employee. Promoting an incentive system that also deals with personal demands, will be an arrangement that ensures that gang members actively participate and are inspired to complete tasks (Min et al., 2017).

> *"There is a need to boost the morale at the terminal by returning the incentive scheme we know, and the big TV screens must be used to display the moves for a shift after every hour to make us aware of our performance towards the target." P5*

According to the participants, an appropriate incentive system should include monetary and non-monetary compensation to motivate them achieve higher efficiency levels and will curb absenteeism at the Transnet Port of Durban. The incentive system at the Transnet Port of Durban is linked to the ship working hour (SWH) target of 60 hours and 32 Gross Crane Moves per hour (GCH) for the gang members (Transnet Port Terminals, 2013b). Management is convinced that the current system is acceptable to the business and staff. The incentive is derived from the Container Terminal Operations Contract (CTOC) revenue where the shipping lines pay extra due to the contract of having a berthing right at the Transnet Port of Durban, as well as finishing those vessels within the targeted ship working hour (Transnet Port Terminals,

2013a). There is a portion intended to reward gang members on the CTOC revenue, this is over and above their basic salaries.

The employees indicated that the current incentive system is ambiguous and prefers "R5 per box" incentive to be brought back. The incentive system at Transnet Port of Durban is apparently not appealing now. It does not inspire gang members to produce high efficiency levels. The throughput volumes are average or below average, this is indicative that an incentive system is in fact inadequate (Naidoo, 2021). In the R5 per box incentive, the driver is clear that there are eight moves of cargo required for every 15 minutes on the equipment. This can also be explained as, every cargo moved after the 36 initial moves in an hour are what the driver will pocket as an incentive. In this way, the gang members can calculate extra moves they have made, keep records of extra container box they moved and equate that into monies they will earn at the end of the shift.

> *"The current incentive scheme is the best as it is linked to productivity in the organization. It is performance based on volumes, it is ideal, and employees will adjust to it sooner rather than later. We also introduced a shift competition system that rewards employees with gifts to motivate them and recognize their performance." P1*

> *"There is a bonus system based on vessel performance targets, these bonus monies are from the customer for reducing ship berthing time. If the targets are met, bonus is paid to Transnet. It is the same money that we want our bonuses paid from as employees." P6*

Apparently, incentive system should intensify gang member loyalty with the port, which will in turn lead to increased throughput, job satisfaction, reduced absenteeism, reduce staff turnover, etc (Oguti, 2017). This is not the case at Transnet Port of Durban even though incentive system is part of collective agreement with bargaining members, CTOC targets are not achieved. It is incumbent on management to establish the reasons why an existing motivation for better performances is not working. There could be a plethora of causes, but for Transnet Port of Durban to remain competitive on a global scale, these causes need to be addressed with speed.

4.10 Response Rate

The researcher selected a total of ten experts as a population of the study, and all ten participants accepted the invitation to be part of the study. The researcher made courtesy calls to each participant reminding them about scheduled interview session and to confirm nothing has changed. The response rate for this study was excellent (100 %) as the participants were eager to get involved in the study. All ten experts were interviewed in MS Teams. The duration of

MS Teams interviews was approximately one hour each. All interviews were conducted in English by the researcher between 28 March 2022 and 22 April 2022. There was a relaxed mood during the interviews, with no interruption as the interview appointments were agreed in advance.

4.10.1 Participants

The participants are categorized in Table 4.3 with a participant code P1 to P10. They are referred to as P1 to P10 in the presentation of results for reference purposes where P1 is the first participant and P10 is the tenth participant. The demographic composition of the participants are seven males and three females of which the three are within a 31 – 40 age group category, six are within a 41 – 50 category and only one is within a 51 – 60 category. Sixty percent of the population were participants from the ICT department and Operations department had a forty percent representation. The participants are very experienced and knowledgeable to provide relevant answers to questions presented, forty percent are in possession of an undergraduate degree qualifications, thirty percent possess postgraduate degree qualifications, twenty percent possess a national diploma qualification and only one percent possess a matric certificate. A detailed information is available on Appendix E – Demographics.

Table 4. 3: Participant Category

Participant Code	Participant Category	Education Level	Age Group
P1	Terminal Manager[1]	Masters	41 – 50
P2	Business Analyst[1]	Matric	51 – 60
P3	Systems Engineer[1]	Degree	41 – 50
P4	Business Analyst[2]	Degree	31 – 40
P5	General Manager[1]	Masters	31 – 40
P6	Systems Engineer[2]	Degree	31 – 40
P7	Navis Consultant	Honours	41 – 50
P8	Executive Manager	B-Tech	41 – 50
P9	General Manager[2]	Degree	41 – 50
P10	Terminal Manager[2]	Degree	41 – 50

4.11 Reliability and Validity

A pilot study was conducted to ascertain whether the research instrument was clear and determine if the research would yield the type of data correlating with literature. Furthermore, reliability establishes whether the type of data could be examined in detail, in relation to the stated research questions in chapter 1. Leedy and Ormrod (2019) also argued that if a research instrument has a gap that is discovered, conducting a pilot study offers an opportunity to change the research instrument. This reduces the need for the researcher to contact the respondents for clarification or to seek more information. It also eliminates the danger of having to discard some of the data because it failed to accurately assess the desired outcome. The research instrument of the study did not require any updates due to the feedback from the findings of the pilot study. The findings of the pilot study collaborated with literature and proved the validity of the research instruments and the researcher's understanding most of the items as intended.

4.11.1 Reliability

Reliability confirms the extent to which data gathering technique consistently produce results that are like those other researchers might produce (Saunders et al., 2019). Leedy and Ormrod (2019) also argued that consistency between the research instrument's output and the research findings is checked for reliability, suggesting that the study should give identical results when carried out by a different researcher. Moreover, Neuman (2016) further states that reliability enables a research tool to consistently deliver similar results throughout time.

Neuman (2016) also argued that alternative form reliability enables the use of two or more research instruments, either in simultaneously or after each other to the same group or distinct groups. In this instance, the research instrument is utilized to gather data and the researcher compared the interview questions' content with secondary data sources like Navis Sparcs N4 and SAP to make sure that accurate information had been obtained.

The researcher obtained data from dependable sources, top management and system specialists from operations and ICT departments. The focus was on executive managers, general managers, terminal managers, systems engineers, business analysts and a consultant because these cohorts are experts on the topics covered in this study and have a decision-making authority at the Transnet Port of Durban.

The researcher made sure that the study's validity and dependability is maintained using MS Teams where the interviews were recorded and stored. The presentation of a consent form

outlining the study's objectives, participants' right to anonymity and confidentiality, and the topics covered. The researcher asked the relevant questions in a tone that is suitable; creation of several question types; proper conduct and good posture during the interview. The researcher and participants demonstrated a good communication skill during the interview which enabled effective review of the topics covered to ensure understanding. However, the researcher had a plan to deal with challenging interviewees through capturing information using notes during the interview and audio post the interview to ensure data dependable.

4.11.2 Validity

Validity describes how well data gathering techniques measure what they were designed to measure (Saunders et al., 2019). According to Bryman and Bell (2015), validity examines if the research accurately measures what it is supposed to establish. The interviews were sufficient, and the research instrument included all areas of the investigation. The research instrument was designed to be simple and straightforward to make sure that participants understand the questions and respond with certainty.

To test whether the research instrument is accurately measuring what it needs to measure, a pilot study was carried out with system engineers and a terminal manager who oversee Navis TOS operation at the Transnet Port of Durban. Before deciding on the final study instrument, the researcher conducted three pilot interviews to gather qualitative data using semi-structured interviews. According to Majid et al. (2017), a properly completed pilot study ensures methodological correctness, ensuring the validity of a study's methodology. A study by Majid et al. (2017) also shows that using pilot studies can help find potential flaws and minimize them.

4.12 Chapter Summary

This chapter analysed the findings and the results of this qualitative study for detailed discussion. The findings of the study of data deduced that planning of operational activities is an important task at the Transnet Port of Durban, and it is directly linked with the port capability to improve efficiency. However, the human resources are inadequate at times, some shifts run without the required skill set and experience to carry out the operational tasks. It is therefore important that through Transnet Academy's Maritime School of Excellence, the overhead lifting equipment and Navis TOS training are prioritized to unlock system competency gaps at Transnet Port of Durban. Once the Transnet Port of Durban employees are certified as competent, they need to fully utilize the Navis TOS to leverage on job sequence of the deployed

work instructions in the system to able to keep up with the pace of required moves per hour to achieve the set targets (Renken et al., 2018). An improved equipment reliability which is derived from an adequate maintenance strategy, the overall operational tasks execution will result into a better-quality service of moving cargo at operations. The current operational technology plays a significant role in operational efficiencies at the Transnet Port of Durban, even though there is still a room for improvement to draw more benefits from what is already available on TPTs operational technology (Vrakas et al., 2021). The next chapter will discuss results on technological improvement, business process to employees and managers at the Transnet Durban Port.

CHAPTER FIVE – DISCUSSION OF RESULTS

5.1 INTRODUCTION

In this chapter the main goal is to draw results, interpret data and discuss research questions of the study guided by literature on the terminal operating system efficiencies. This discussion ultimately augments a solution that connects the research objectives to the recommendations of the study. The emerged themes in the study attest that the strategic positioning of Transnet Port of Durban along international shipping networks confirms desirable efficiency levels are achievable.

5.2 Discussion

An important metric of port performance is efficiency, as a result, more efficient ports reduce transportation costs and make it easier for shipping companies to import and export goods through global logistics chain (Setiawan et al., 2018). Based on the study objectives in chapter one, a terminal operating system literature review and a thorough data analysis are critical in exploring the efficiency of the Navis Terminal Operating System at the Transnet Port of Durban. The research model of the study integrated AST, TTF and TOE models to address the efficiency challenges at the Port of Durban. The existing literature in container terminal productivity, terminal operating system efficiency and collected data tackled the following research questions:

5.2.1 RQ1

What is the impact of workload on operational efficiency of the Navis TOS at the Transnet Port of Durban Terminal?

Some of the port operation tasks that influence efficiency are berthing time, gross crane moves per hour and shift handover. The operational performance of the different shifts is tracked at every hour and the average performance is 26 gross crane moves per hour. The shortage of gang members for different shift is the main reason of underperformance. Transnet Port of Durban must recruit additional human resources to enable each shift to operate with 14 gang members. This will assist the port to achieve 32 gross crane moves per hour and even more. The ship working hour target of 60, however the average is 72 hours if the port is performing “better” in recent times. The cause of delays is failing to complete assigned jobs in time at marine service from the authority side and yard operations from the operator. The two-hours on or off swaps for the operators are not well coordinated during handover. The use of green

area talks resolves all communication breakdown and improves adherence to standard operating procedure amongst the shifts.

A comprehensive approach to streamlining the workload at Transnet Port of Durban ensures that the Navis TOS has no adverse impact on the operational efficiency (Transnet Port Terminals, 2013a). The system is capable of handling vast quantities of data and can process multiple business processes, transactions, and work instructions simultaneously if the human resources possess the required skills to use the system. The available system infrastructure like application servers and back-office databases are capable to adequately host and run the deployed technology with only just 0.00005% unexpected system related interruptions for the whole year except for three days (New Year's Day, Workers' Day, and Christmas Day) in a year dedicated to system maintenance. Due to the ageing fleet, maintenance activities are done daily as and when needed which somehow hinder port efficiency but demonstrate Navis TOS ability to handle the workload.

5.2.2 RQ2

What is the extent of Navis TOS utilization in optimizing operational efficiency at Transnet Port of Durban Terminal?

According to Transnet Port Terminals (2013a), the Navis TOS is not fully utilized to optimise the operational efficiency at the Transnet Port of Durban. The analysis of the study suggest that the system users are trained, assessed, and then granted system access after achieving a certain score threshold in Navis TOS assessment to assume competency of being a system user. However, the operators of overhead lifting equipment are on the basic level of using the TOS and lack the critical skills needed to use the TOS to its full potential. As a result, there is a disconnect on the Transnet Port Terminals return on investment to achieve world-class terminal operations and to improve South African harbours efficiencies.

Transnet Port Terminals customers with container terminal operations contract agreement pay an extra premium of 10% if a ship working hour target of 60 hours is achieved (Transnet Port Terminals, 2013b). This extra revenue was equally shared with a whole value chain at terminal operations, and that kept everybody inspired to accomplish greater output number on the respective shifts. The change of Transnet leadership impacted the operating model that produced good performances at the terminal operations level. Subsequently to the operating model changes, the performance suddenly declined as the incentive earned from achieving ship working hour targets ceased to exist. The employees' morale has been going down and the

willingness to learn and improve their technological knowledge to positively contribute to the operational efficiency is non-existent.

5.2.3 RQ3

What is the impact of throughput on the performance of the Navis TOS in improving operational efficiency at Transnet Port of Durban Terminal?

The use of available technology at Transnet Port of Durban assimilates GCOS, SAP ERP, EDI and CAMCO to maximise throughput on the Navis TOS to an above-average effect on improving operational efficiency through an end-to-end performance, as well as application architecture (Vrakas et al., 2021). The TOS works very well in real-time which assures data integrity and consistency across the board, but this study found that the unreliability of fibre connection in the yard has detrimental consequences in operational efficiency. Transnet Port of Durban have not been able to migrate to cloud or to utilizing software as a service (SaaS) which would reduce the maintenance overheads (Heilig & Voß, 2017). So, it is affecting the Port of Durban in terms of costs that the connectivity might be there, but there is no reliability, or the speed is not fast enough to have a real time database transmission at a required level for the Transnet Port of Durban.

In as much as the TOS can work well on the local area network (LAN), there is a communication gap for sharing and coordinating real live information as the gang members on the ground (mainly the planners, cargo coordinators, operators of overhead lifting equipment and supervisors) rely on radio communication mostly to converse with the planning team at the admin office building. The modern smart televisions are available to display the real-time data and key performance indicators on internal dashboards, but they are currently not fully integrated with the Navis TOS. There are new add-ons that the Transnet Port of Durban can use in terms of Navis, such as N4 PrimeRoute and SmartAccess modules (Pelevic et al., 2022 May). These are optimization modules that can be incorporated into the existing Navis TOS to improve efficiencies, the way work instructions are dispatched, the way next moves are calculated, and the way the containers are planned in the yard.

5.2.4 RQ4

What is the relationship between the actual utilization of the Navis TOS and operational efficiency at Transnet Port of Durban Terminal?

The Navis Sparcs N4 system generally has a positive impact in improving operational efficiency as it is configured to incorporate the Standard Operating Procedures of TPTs

container terminals (Pelevic et al., 2022 May). This enables TPTs business community to view estimated time of arrival or departure, track and trace containerized cargo that might have been accelerated by rail or road and monitor the arrival and departure of trucks. TOS offer customers the flexibility to release EDI message for the exclusion of a container and a pre-announcement EDI message for the distribution of a container. TPTs also gives a direct internet link so that customers can login to the Navis TOS web portal and complete the release and pre-announcement of cargo (Transnet Port Terminals, 2013a). Through Navis TOS, Transnet Port of Durban innovated to use the Rail Dual Cycle technique. This allows the Transnet Port of Durban gain operational visibility and maximize the use of driver articulated vehicle, straddles, and rail mounted gantries by enabling them to always run loaded, improving loading and discharge times and therefore increasing operational efficiency.

5.2.5 RQ5

How useful are the available technologies in executing operational tasks to improve efficiency at Transnet Port of Durban?

Transnet Port of Durban has been struggling to keep up with the demands for performance and continuously increasing cargo volumes. For a port to improve, maximum utilization of TOS is fundamental in today's terminal operations as it supports planning, scheduling, and equipment control. All operational tasks like stowage planning, grounding decisions and equipment dispatching should be performed by the terminal operating system to enhance port efficiency (Heilig & Voß, 2017).

A performance scorecard for employees and management must support container terminal strategy, align the activities, and identify the business value that is obtained through the improvement in operational efficiency. The upskilling of human resources at the Port of Durban should prioritize terminal operating system and terminal equipment training to ensure continuous integrated container terminal operations. The management should minimize downtime for maintenance. Preventative maintenance enables increased asset life, safety compliance, and proactive corrective actions (Pelevic et al., 2022 May). The technical department should be proactive in anticipating potential failures so that pre-emptive investigations, modifications to the maintenance plan, and repairs can be made before the asset breaks and reduces downtime and increase efficiency.

Lee and Kim, (2013) postulate that numerous stacking strategies should be used, considering the equipment that is available and the members of the gang present, to increase the overall performance of the terminal. Use of portable devices like tablets for employees in operations

to manage cargo around the terminal and speed up cargo handling in yard operations. Another way close to employees at the Port of Durban to improve efficiency and counter challenges, is an unambiguous incentive system, shift pattern (changes), reliable equipment availability and visible display screens in the port showing live target updates and terminal. The list enables a 32 gross crane moves per hour, ship working hours of 60 or less with a gang of 14 members per shift on the allocated berth (Transnet Port Terminals, 2013a).

5.3 Recommendations

The researcher makes the following recommendations based on the findings from a study for the efficiency of the Navis Terminal Operating System at Transnet Port of Durban, South Africa. The recommendation support ease of access for cargo at any given time on connected device and seamless integration.

5.3.1 To Employees

Transnet Port of Durban management and organised labour should find a common ground to effectively lead the terminal employees and inculcate the five Transnet principles of honesty, safety mindset, reward of good work, dignity, and respect principles (Transnet Port Terminals, 2013b). Through a unified leadership collaboration, management and organised labour must lead the Transnet Port of Durban employees in executing the assigned tasks with absolute dedication and complete earnestness.

5.3.2 To Managers

To bring about the desired efficiencies, Transnet Port of Durban need to be driven by incentive schemes as this is norm for best performing ports around the world. The gang members on the ground have a huge potential to influence turnaround times in terminal operations chain, therefore adopting an incentive scheme linked to efficiency is the winning formula for all parties at the Transnet Port of Durban.

Establish a permanent centre of excellence that would be responsible for maintenance, repair, and service equipment at Transnet Port of Durban. The centre of excellence should be capacitated with skilled people that have right attitude to turnaround and maintain equipment to run an efficient terminal operation. The centre should be given necessary support from the management team, all the way to supply chain department by ensuring enough stock of spares and consumables are timeously available to enable the maintenance of the available equipment.

Adherence the routine planned maintenance and service regimes must be the order of the day, otherwise consequence management process should be instituted for any disregard of the critical maintenance procedures.

5.3.3 For Technological Improvement

In the era of smart technology, the automation and digitalization are increasingly emphasized (Adabere et al., 2021). According to Transnet Port Terminals (2013b) "emerging" technologies like Internet of Things (IoT), Big Data, Artificial Intelligence (AI) etc are interrelated to each other and jointly contribute into improving port efficiency at the Transnet Port of Durban. Technologies pertaining to transport subsystems play a significant role in the development of container terminals. These technologies are predicated on reducing the amount of time that containers must be retained at the terminal, optimizing the distance travelled, and minimizing power consumption and environmental pollution (Transnet Port Terminals, 2013b).

Deployment of appropriate technology gives real-time data to report correct decisions. It can promote greater productivity, support compliance, lower operating expenses, improve oversight throughout the entire operation, and guarantee that strict safety and equipment maintenance schedules are followed. In addition, shift supervisors must review performance of each gang member for the assigned tasks. In instances where a gang member is not meeting their targets, supervisors must mentor, and coach an affected gang member to assisting him or her achieve set targets. The critical skills in container terminal operations are currently in short supply which results in a limited capacity for affected shifts (Iyer & Nanyam, 2021). In some cases, this is due to trained personnel leaving Transnet for better opportunities outside the country, after being skilled through Transnet Academy Maritime School of Excellence hence the continuous need to fill the gaps. Supervisors must be trained on how to deal with underperforming gang member to uplift their performance through upskilling, mentoring, and coaching. World Bank (2021) concedes that skilled container terminal gang members are on demand and migration of skills is setting back container terminals that continuously develop their workforce.

5.3.4 For Business Process

An expeditious procurement of an additional 45 equipment, the straddle carriers to be precise, to enable Transnet Port of Durban capability of handling cargo with sufficient machinery for the projected TEUs (Oguti, 2017). Remove equipment that has reached its useful life in the terminal operations yard to ensure equipment availability and reliability in the port because

critical operational areas require a dedicated amount of equipment for efficient execution of operational tasks. Therefore about 48 straddles are needed under ship-to-shore cranes and 27 for housekeeping in the terminal yard.

Transnet Port of Durban need to be increasing the number of gang members working into a 14-gang manning a berth and introducing an hourly management system where performance is monitored every hour per equipment and per individual for the desired efficiencies (Transnet Port Terminals, 2013b).

Diagnostic testing is the main critical issues in equipment maintenance where the analysis of the root cause of equipment failure is carried out. The purpose of diagnostic testing is to provide relevant solutions to the problem and prevent similar problem from recurring in future by creating equipment data bank for future use. Diagnostic time need to be monitored against the equipment being tested, where four hours to complete diagnosis is an average in a big equipment. The variation of time taken based on the age, complexity and physical size of the equipment, the tools used, and skill set level at technical department should be addressed by port maintenance strategy. The analyses must be discussed during green area talks. The Lean Six Sigma methods must be deployed to analyse problems and identify a root cause through collaborative fishbone tool or the 5 why approach tool.

5.4 Chapter Summary

The Transnet Port of Durban Navis TOS journey (challenges, solution, and solution outcome) demonstrates how Transnet Port Terminals management could capitalized on the effectiveness of Navis TOS to influence cargo turnaround times at the port is illustrated by Figure 5.1 (Appendix I). The Navis TOS agility mitigates communication breakdown between customers and the Transnet Port of Durban employees through web portal access for external users. Transnet Port of Durban improved operations planning and visibility which resulted into greater insight for terminal supply chain (both with landside and seaside operations), customer engagements and accurate reporting through Navis TOS. Through the business intelligence technologies, Transnet Port of Durban is continuously improving seaport management of cargo handling to maximize operational efficiency and are on track to become a busiest container terminal in the Southern Hemisphere.

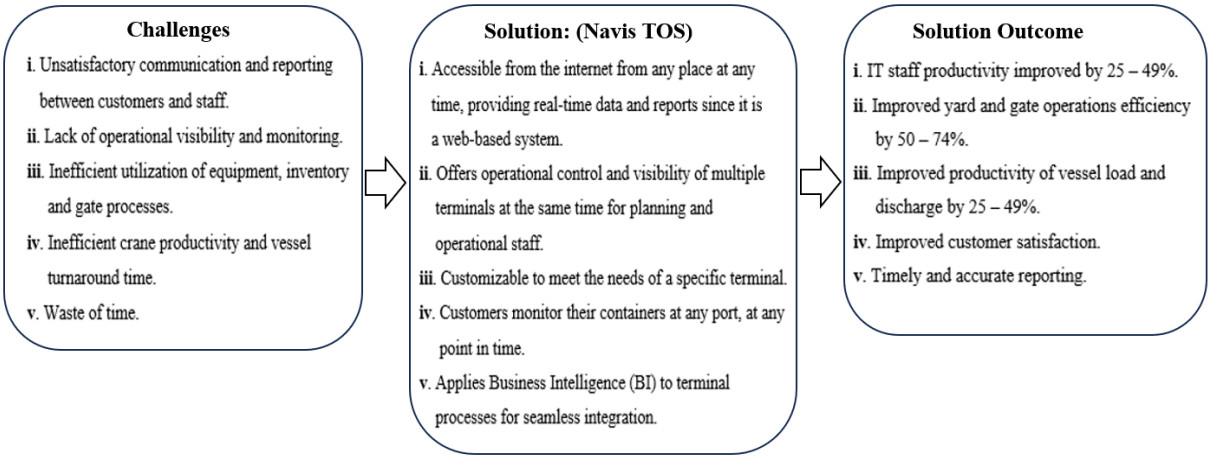

Figure 5. 1: Transnet Port Terminals Navis TOS Journey
Source: Authors Own Design

This study was focused on exploring the efficiency of the Navis Terminal Operating System at the Transnet Port of Durban. However, the operating division Transnet Port Terminals was somehow linked because it drives ICT strategy for terminal operations at the Port of Durban. The Navis TOS is capable of handling huge workloads without stress, and the study found that it is not fully utilised and optimised to enhance higher operational efficiency. The system users require upskilling to draw value on TPTs return on investment of TOS from an undisputed market leader and fully utilise the available operational technology. The TOS has no relation to other factors affecting efficiencies such as reliable equipment and the morale of the gang in general.

The five research questions were summarized into impact of workload on operational efficiency, optimizing operational efficiency, impact of throughput on the performance, actual utilization, and the usefulness of the available technologies at the Port of Durban terminal operations. The gathered data sufficiently answered all the questions on how operational tasks are planned and executed through the TOS. The communication methods (green area talks and shift indabas) deployed at different terminal levels support operational efficiency targets. The level of performance for existing technologies were noted to be the right fit for purpose but not fully utilized to optimize Transnet terminal operations and leverage on Navis global standard. The lack of system enhancements and upgrading to the highest level of system capability, like integrating N4 PrimeRoute and SmartAccess modules to draw full return on investment are the opportunities Transnet Port of Durban terminal management should pursue to improve efficiency. The financial challenges are a notable hindrance to retaining critical skills required for both the TOS and the procurement of equipment thereby adversely affecting terminal efficiencies.

CHAPTER SIX – CONCLUSION, LIMITATIONS AND FUTURE RECOMMENDATIONS

6.1 INTRODUCTION

This chapter delves into the findings and insights collected from the comprehensive study exploring the efficiency of the Navis TOS at Transnet Durban Port. Subsequently, this section succinctly articulates future directions to pave the way for the actionable strategies. These recommendations not only address the identified limitations but also serve as a catalyst for transformative advancements in port operations. In essence the study identifies investment on port infrastructure, procurement of equipment and development of Navis TOS competencies as priority for the Transnet Durban Port

6.2 Limitations of Research

Aspers and Corte (2019) explain limitations as constraints of a study approach. For the purposes of ensuring dependability, this study's data analysis procedure was deductive. The literature conducted to arrive at the study's conclusions could not have been sufficient to explore the efficiency of the Navis TOS at Transnet Port of Durban. The organizational slack can lead to communication practices that hinder effective technology utilization.

In this study the population was 10 Transnet employees from ICT and Operations departments with decision-making authority in Navis TOS due to operational commitments. Since the participants are employees of Port of Durban, interviews were during office hours or just after end of shift and limited to 60 minutes as per MS Teams schedule. The other limitation into the study was COVID-19, the researcher had to comply with COVID-19 regulations. There was no opportunity for a physically meeting with the participants hence the interviews were on a virtual platform, Microsoft Teams.

6.3 Future Recommendation

Accordingly, future research comparing this study's findings and other studies across the similar ports to Transnet Port of Durban will be significant for efficiency. There is no available data on terminal operating systems proficiency from South African ports perspective. Therefore, delving deep into port operations tasks like berthing, loading, and unloading within a contracted vessel turnaround time will improve port efficiency. In addition, future research should focus on the operational efficiencies to indicate the impact ports have on the country's gross domestic product as a state-owned company. The scholars can further unpack the importance of port efficiency in improving trade facilitation in the Southern African

Development Community region and then the rest of Africa through ports as they set the tone for trade and economic growth prospects. More research can establish how investment in port infrastructure is the solution to the capability challenges of African ports to accommodate vessels and efficiently complete the berthing, loading, and unloading, and other activities within a contracted vessel turnaround time.

Using big data analysis and cloud-based platforms can provide great advantages to port operations, especially in improving efficiency, when implemented by Navis. This could offer Transnet Port of Durban valuable insights from large amounts of operational data, such as vessel movements, cargo handling processes, and supply chain dynamics when Navis TOS utilize big data analytics. The knowledge could help Port of Durban enhance resource distribution, simplify operations, and enhance decision-making. Combining big data analytics and cloud technology can improve port operations, boosting competitiveness and sustainability in the global maritime industry.

6.4 Implication of the study

For Transnet to provide efficient and reliable services that meet the needs of the customers (shipping lines), maintaining the infrastructure as well as the superstructure of the Port of Durban should be priority number one. The Transnet Port of Durban need to concentrate on reducing equipment downtime and focus on improving the level of compliance to maintenance schedules and reduce unplanned and ad hoc maintenance on cranes (Oguti, 2017). The efficiency of the port is dependent on the available technology, skillset of the gang and equipment availability as well as its reliability thereof. Transnet Port of Durban need to optimize yard operations through:

a) Investment on port infrastructure and the superstructure to contribute to economic growth;
b) Procurement of sufficient equipment to execute the operational tasks to achieve two million TEUs per year;
c) Improve TOS competency levels for gang members, integrate N4 PrimeRoute and SmartAccess modules for an efficient terminal operation.

These may take some time as it would require substantial capital investment and Transnet need government support because it operates within public service port model.

6.5 Chapter Summary

The strategic positioning of Transnet Port of Durban along international shipping networks guarantees desired efficiencies that are at its fingertips if the recommendations of this study are implemented. In general, this involves a decision to fully support software based on optimization algorithms for more effective scheduling and planning operational transactions (Heilig & Voß, 2017). In addition, big data analysis and the utilization of cloud-based collaborative platforms are currently popular developments (Adabere et al., 2021). Transnet Port of Durban can be great again and drive the economy of South Africa and other Southern African Development Community nations.

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APPENDIX A – ETHICAL CLEARANCE

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

22 March 2022

Msawenkosi Eric Ngubane (219060312)
School Of Man Info Tech & Gov
Westville Campus

Dear ME Ngubane,

Protocol reference number: HSSREC/00003869/2022
Project title: Exploring the efficiency of the Navis Terminal Operating System at Transnet Durban Port, South Africa
Degree: Masters

Approval Notification – Expedited Application

This letter serves to notify you that your application received on 17 February 2022 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) 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.

This approval is valid until 22 March 2023.
To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

All research conducted during the COVID-19 period must adhere to the national and UKZN guidelines.

HSSREC is registered with the South African National Research Ethics Council (REC-040414-040).

Yours sincerely,

[redacted]

Professor Dipane Hlalele (Chair)

/dd

Humanities and Social Sciences Research Ethics Committee
Postal Address: Private Bag X54001, Durban, 4000, South Africa
Telephone: +27 (0)31 260 8350/4557/3587 **Email:** hssrec@ukzn.ac.za **Website:** http://research.ukzn.ac.za/Research-Ethics
Founding Campuses: Edgewood Howard College Medical School Pietermaritzburg Westville

APPENDIX B – GATEKEEPERS RESPONSE LETTER

15 December 2021
11 John Geekie Road
Glenmore
Durban
4001

219060312@stu.ukzn.ac.za

Dear Musa Ngubane,

Re: Request for permission to conduct research at Transnet SOC Ltd

Your email of request for permission to conduct research at Transnet on "Exploring the efficiency of the Navis Terminal Operating System (TOS) at Transnet Durban Port, South Africa" is acknowledged.

We note the conditions of the study for strict academic purposes, the results of the study will be submitted to Transnet, and the research will be confidential and that anonymity for both respondents and the organisation is guaranteed. Should you or University of KwaZulu-Natal want to publish the study in any other manner than the final assignment, Transnet will be approached for permission to do so.

Based on the above conditions, your request to conduct the research study in Transnet is granted. We are looking forward to the outcomes and recommendations of your study and the positive contributions towards the strategy of Transnet.

[redacted]

Mr. Itumeleng Matsheka
Chief of People Management & Learning
Date: 23/12/2021

APPENDIX C – INFORMED CONSENT FORM

Information Sheet and Consent to Participate in Research

Date: 27 January 2022

Dear Prospective Participant

My name is Musa Ngubane, a student at the University of KwaZulu-Natal (UKZN) studying towards Master of Commerce in Information Systems and Technology degree in the School of Management, Information Technology and Governance. My contact details are 081 045 5169 (Cell number) and 219060312@stu.ukzn.ac.za (email).

You are being invited to consider participating in a study that involves research about the efficiency of the Navis Terminal Operating System (TOS) at Transnet Port of Durban in South Africa. The aim and purpose of this research is to determine the impact of throughput on the Navis TOS in improving operational efficiency at Transnet Port of Durban Terminal. The study is expected to enrol 18 participants at Transnet Durban Container Terminal. It will involve the interview procedures for data collection. The duration of your participation if you choose to enrol and remain in the study is expected to be forty-five (45) to sixty (60) minutes.

The study may involve the risks of exposure to COVID-19 where in contact interviews are conducted, however physical contact (where required) will be in accordance with social distancing and COVID-19 Regulations. The study will provide no direct benefits to participants. The results of the study are intended to contribute to explore the efficiency of the Navis TOS at Transnet Port of Durban in South Africa.

Your participation in this study is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this study. Confidentiality and anonymity of records identifying you as a participant will be maintained by the School of Management, Information Technology and Governance, of UKZN and disposed of according to university policy.

This study has been ethically reviewed and approved by the UKZN Humanities and Social Sciences Research Ethics Committee (HSSREC/00003869/2022)

In the event of any problems or concerns/questions you may contact the researcher at (at 081 045 5169 or 219060312@stu.ukzn.ac.za) or the UKZN Humanities & Social Sciences Research Ethics Committee, contact details as follows:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION
Research Office, Westville Campus
Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604557- Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

CONSENT TO PARTICIPATE

I _____ have been informed about the study entitled **Exploring the efficiency of the Navis Terminal Operating System (TOS) at Transnet Durban Port, South Africa** by Musa Ngubane.

I understand the purpose and procedures of the study.

I have been given an opportunity to ask questions about the study and have had answers to my satisfaction.

I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any of the benefits that I usually am entitled to. I also give consent to the audio recording of my interview.

If I have any further questions/concerns or queries related to the study, I understand that I may contact the researcher at 081 045 5169 and or 219060312@stu.ukzn.ac.za.

If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers, then I may contact:

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Tel: 27 31 2604557 - Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

_____ _____

Signature of Participant **Date**

APPENDIX D – QUESTIONNAIRE

Part 1 Research Instrument Employees File:

Exploring the efficiency of the Navis Terminal Operating System (TOS) at Transnet Durban Port, South Africa.

Student Name: Msawenkosi Ngubane

Student Number: 219060312

Email: 219060312@stu.ukzn.ac.za

Supervisor: Prof Prabhakar Rontala Subramaniam

Ocean economy is the backbone of global trade in which maritime transportation accounts for more than eighty percent of international trade volume, which is a massive volume handled every day by ports worldwide. Port efficiency is an important aspect that inspires port competitiveness and increases regional development. The Terminal Operating System (TOS) supports terminal operators to improve operations and better strategize gate planning, equipment control, and ground stowage from seaside and the landside. It is critical that the Durban Port avoids diversion to neighbouring ports because of efficiency in port operations. Furthermore, by providing high equipment performance, large storage capacity and reducing berth times and delays, the Durban Port will retain the hub-status of transhipment volumes in Southern Africa.

It is the purpose of this study to explore the efficiency of the 'Navis' Terminal Operating System towards improving seaport management in cargo handling at Transnet Port of Durban.

CONSENT TO PARTICIPATE

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KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604557 - Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

_____ _____

Signature of Participant **Date**

Scheduled Interview Questions

SECTION A: DEMOGRAPHICS

A 1. Gender

Male	Female	Prefer not to answer

A 2. Age Group

18-30 years	31-40 years	41-50 years	51-60 years	61 years & above

A 3. Department presently working in within Transnet

Operations	Engineering	Finance	IT	Other: specify

A 4. Position presently held at Transnet

Chief Executive	General Manager	Executive Manager	System Engineer	Other: specify

A 5. The nature of employment status

Permanent	Temporary	Contracted

A 6. Education qualification/background

Matric or below	National Diploma	University Degree	Postgrad Qualification	Master's Degree	Ph.D.

A 7. Number of years working at Transnet

Years

SECTION B: BUSINESS CAPABILITY

B 1.1. What difficulties do employees face when performing tasks in a shift at the Transnet Durban Port?

B 1.2. What are the inconveniences in operational plans implemented to achieve the targeted gross crane moves per hour (GCH) at the Transnet Port of Durban?

B 1.3. What must be done to reduce the ship berthing time at the Transnet Port of Durban?

B 1.4. What is a popular shift in terms of preference amongst employees at the Transnet Durban Port, and why?

B 1.5. What are the areas of improvement in your shift to enable better performance?

B 1.6. What assistance is available to ensure that tasks are achieved on time at the Transnet Durban Port?

B 1.7. How can a shift change or handover be improved at the Transnet Port of Durban?

B 1.8. How comparable is the incentive system available to motivate employees to achieve daily targets at the Transnet Port of Durban?

B 1.9. If there is none, what incentive system would encourage employees to achieve daily targets at the Transnet Port of Durban?

B 1.10. How do the scheduled shifts assist in delivering effective performance for daily tasks at the Transnet Port of Durban?

B 1.11. How realistic are the set targets to be achieved in a shift at the Transnet Port of Durban? For example, gross crane moves per hour.

B 1.12. What is the required gang to man all workstations at operations for a particular berth?

B 1.13. What are the key tasks and their challenges for each gang member of a container handling operation?

B 1.14. What are your comments on the sufficiency of resources available in the yard to service a ship?

B 1.15. How can resources reduce the time of loading or unloading a ship?

B 1.16. How is the availability of resources required to handle Durban Port volumes?

B 1.17. How can berth planning be simplified and made easy for both “Terminal Operator” and “Landlord” planning teams?

B 1.18. How are rostered employees coping with the workload in a shift at the Transnet Durban Port?

B 1.19. What are the gaps in operational processes from planning to yard operations at the Transnet Port of Durban?

SECTION C: PERFORMANCE

C 1.1. How manageable is the execution of preventative maintenance of resources at Transnet Durban Port?

C 1.2. What are the causes of corrective maintenance for resources if technicians (Technical Team) adhere to scheduled preventative maintenance plans at Transnet Port of Durban?

C 1.3. How do you measure the reliability of resources deployed in operations at Transnet Durban Port?

C 1.4. What are the challenges with available resources in enabling optimisation of the terminal capacity at Transnet Port of Durban?

C 1.5. What resources are available for the operations during loading and unloading of cargo aboard the ship at Transnet Port of Durban?

C 1.6. How do the standard operating procedures enhance resource efficacy at Transnet Durban Port operations?

C 1.7. How much time do engineers need to handle high level planning focused towards long-term goals of operations management at Transnet Port of Durban?

C 1.8. What is critical in planning maintenance tasks for each day, in terms of time required by the supervisor at Transnet Port of Durban?

C 1.9. How long does it take a technician to conduct diagnostic testing on a particular resource at Transnet Port of Durban?

C 1.10. How do you analyse the problem and prevent it from reoccurring at Transnet Durban Port?

C 1.11. What is required for the system maintenance that is the backbone of operations at the Transnet Port of Durban?

C 1.12. How frequent is system maintenance, and how long is the duration of scheduled downtime at the Transnet Port of Durban operations?

C 1.13. What are the additional resources that may be required to improve efficiency at Transnet Port of Durban?

C 1.14. What are the resources used to optimally operate at terminal capacity of the Transnet Durban Port?

C 1.15. How is the performance of deployed resources measured to monitor efficiency levels at the Transnet Port of Durban?

C 1.16. How does the Transnet Port of Durban maintenance strategy ensure resources are available on time and ready to operate in full capacity?

SECTION D: TECHNOLOGY & EFFICIENCY

D 1.1. How is the operational technology available to perform port operations tasks at Transnet Port of Durban?

D 1.2. How easy is it to understand and use the operational technology at Transnet Durban Port?

D 1.3. How is the internet speed affecting the completion of operational tasks at Transnet Durban Port?

D 1.4. What is operational technology impact on port operations tasks to improve efficiency of port operations at Transnet Port of Durban?

D 1.5. What is your comment about current levels of efficiency with the existing operational technology at Transnet Port of Durban?

D 1.6. How will the projected Twenty-foot Equivalent Units (TEUs) be handled at Transnet Durban Port based on the available resources?

D 1.7. How can operational technology be customised towards improving efficiency at Transnet Durban Port?

D 1.8. What operational technology enhancement can advance port operations efficiency levels at Transnet Port of Durban?

D 2.1. What is the overarching maintenance system strategy for the resources at Transnet Durban Port?

D 2.2. What are the causes of operational delays at Transnet Port of Durban?

D 2.3. How can existing resources be deployed to improve efficiency at Transnet Port of Durban?

D 2.4. How are critical skills retained at the Transnet Port of Durban to effectively manage the movement of cargo containers?

D 3.1. How sufficient is the operating technology at Transnet Port of Durban for the movement and storage of cargo?

D 3.2. How is the reliability of the operating technology available to perform tasks at Transnet Durban Port?

D 3.3. How is the operating technology affecting current levels of productivity at Transnet Durban Port?

Part 2 Research Instrument Management File

Exploring the efficiency of the Navis Terminal Operating System (TOS) at Transnet Durban Port, South Africa.

Student Name: Msawenkosi Ngubane
Student Number: 219060312
Email: 219060312@stu.ukzn.ac.za
Supervisor: Prof Prabhakar Rontala Subramaniam

Ocean economy is the backbone of global trade in which maritime transportation accounts for more than eighty percent of international trade volume, which is a massive volume handled every day by ports worldwide. Port efficiency is an important aspect that inspires port competitiveness and increases regional development. The Terminal Operating System (TOS) supports terminal operators to improve operations and better strategize gate planning, equipment control, and ground stowage from seaside and the landside. It is critical that the Durban Port avoids diversion to neighbouring ports because of efficiency in port operations. Furthermore, by providing high equipment performance, large storage capacity and reducing berth times and delays, the Durban Port will retain the hub-status of transhipment volumes in Southern Africa.

It is the purpose of this study to explore the efficiency of the 'Navis' Terminal Operating System towards improving seaport management in cargo handling at Transnet Port of Durban.

CONSENT TO PARTICIPATE

I _____ have been informed about the study entitled **Exploring the efficiency of the Navis Terminal Operating System (TOS) at Transnet Durban Port, South Africa** by Musa Ngubane.

I understand the purpose and procedures of the study.

I have been given an opportunity to ask questions about the study and have had answers to my satisfaction.

I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any of the benefits that I usually am entitled to. I also give consent to the audio recording of my interview.

If I have any further questions/concerns or queries related to the study, I understand that I may contact the researcher at 081 045 5169 and or 219060312@stu.ukzn.ac.za.

If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers, then I may contact:

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Tel: 27 31 2604557 - Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

_____ _____

Signature of Participant **Date**

Scheduled Interview Questions

SECTION A: DEMOGRAPHICS

A 1. Gender

Male	Female	Prefer not to answer

A 2. Age Group

18-30 years	31-40 years	41-50 years	51-60 years	61 years & above

A 3. Department presently working in within Transnet

Operations	Engineering	Finance	IT	Other: specify

A 4. Position presently held at Transnet

Chief Executive	General Manager	Executive Manager	System Engineer	Other: specify

A 5. The nature of employment status

Permanent	Temporary	Contracted

A 6. Education qualification/background

Matric or below	National Diploma	University Degree	Postgrad Qualification	Master's Degree	Ph.D.

A 7. Number of years working at Transnet

Years

SECTION B: BUSINESS CAPABILITY

B 1.1. How are tasks to be performed in a shift communicated at the Transnet Port of Durban?

B 1.2. What are the plans to achieve the targeted gross crane moves per hour (GCH) at the Transnet Port of Durban?

B 1.3. How can a ship berthing time be reduced at the Transnet Port of Durban?

B 1.4. What is the performance of different shifts in terms of productivity at the Transnet Durban Port?

B 1.5. What is your suggestion for improving shift productivity at the Transnet Port of Durban?

B 1.6. How are employees who are not achieving tasks on time assisted at the Transnet Durban Port?

B 1.7. What are the challenges with a shift change or handover at the Transnet Port of Durban?

B 1.8. What incentive system is there for employees when daily targets are achieved at the Transnet Port of Durban?

B 1.9. If there is none, what would be an ideal incentive system to encourage employees to achieve daily targets at the Transnet Port of Durban?

B 1.10. How does the shift system accommodate employees to perform daily tasks effectively (in terms of shift numbers, number of employees accommodated in different shifts and duration of the shift) at the Transnet Port of Durban?

B 1.11. What are the set targets for employees to achieve tasks in time at the Transnet Durban Port? And on what basis?

B 1.12. How many gang members are required to run operations effectively for a particular berth?

B 1.13. What do you expect from gang members to execute as key tasks at their manned station?

B 1.14. How are resources planned and deployed to service a ship?

B 1.15. What is the effect of resources in the loading or unloading of a ship?

B 1.16. What is your comment on the requirements and availability of resources to handle Durban Port volumes?

B 1.17. What are the challenges of berth planning and what are mitigating interventions?

B 1.18. How is the workload allocated between different shifts at the Transnet Port of Durban?

B 1.19. How seamless are the processes in relation to the tasks performed by the planning team, all the way to the team of lifting equipment operators at the Transnet Durban Port?

SECTION C: PERFORMANCE

C 1.1. How manageable is the execution of preventative maintenance of resources at Transnet Durban Port?

C 1.2. What are the causes of corrective maintenance for resources if technicians (Technical Team) adhere to scheduled preventative maintenance plans at Transnet Port of Durban?

C 1.3. How do you measure the reliability of resources deployed in operations at Transnet Durban Port?

C 1.4. What are the challenges with available resources in enabling optimisation of the terminal capacity at Transnet Port of Durban?

C 1.5. What resources are available for the operations during loading and unloading of cargo aboard the ship at Transnet Port of Durban?

C 1.6. How do the standard operating procedures enhance resource efficacy at Transnet Durban Port operations?

C 1.7. How much time do engineers need to handle high level planning focused towards long-term goals of operations management at Transnet Port of Durban?

C 1.8. What is critical in planning maintenance tasks for each day, in terms of time required by the supervisor at Transnet Port of Durban?

C 1.9. How long does it take a technician to conduct diagnostic testing on a particular resource at Transnet Port of Durban?

C 1.10. How do you analyse the problem and prevent it from reoccurring at Transnet Durban Port?

C 1.11. What is required for the system maintenance that is the backbone of operations at the Transnet Port of Durban?

C 1.12. How frequent is system maintenance, and how long is the duration of scheduled downtime at the Transnet Port of Durban operations?

C 1.13. What are the additional resources that may be required to improve efficiency at Transnet Durban Port?

C 1.14. What are the resources used to optimally operate at terminal capacity of the Transnet Durban Port?

C 1.15. How is the performance of deployed resources measured to monitor efficiency levels at the Transnet Port of Durban?

C 1.16. How does the Transnet Port of Durban maintenance strategy ensure resources are available on time and ready to operate in full capacity?

SECTION D: TECHNOLOGY & EFFICIENCY

D 1.1. What operational technology is available to perform port operations tasks at Transnet Durban Port?

D 1.2. How has operational technology been made easy to understand and use by employees at Transnet Port of Durban?

D 1.3. What is the internet speed specification details for the operational technology at Transnet Port of Durban?

D 1.4. How does the operational technology enable execution of port operations tasks to improve efficiency of port operations at Transnet Port of Durban?

D 1.5. What is your view of the existing operational technology, in terms of the current levels of efficiency at Transnet Port of Durban, in comparison with international standards?

D 1.6. How will the projected Twenty-foot Equivalent Units (TEUs) be handled at Transnet Durban Port based on the available resources?

D 1.7. What customisation would you suggest for the operational technology system towards improving efficiency at Transnet Port of Durban?

D 1.8. How can operational technology enhancement advance port operations efficiency levels at Transnet Port of Durban?

D 2.1. What is the overarching maintenance system strategy for the resources at Transnet Durban Port?

D 2.2. What are the causes of operational delays at Transnet Port of Durban?

D 2.3. How can existing resources be deployed to improve efficiency at Transnet Port of Durban?

D 2.4. How are critical skills retained at the Transnet Port of Durban to effectively manage the movement of cargo containers?

D 3.1. How sufficient is the operating technology at Transnet Port of Durban for the movement and storage of cargo?

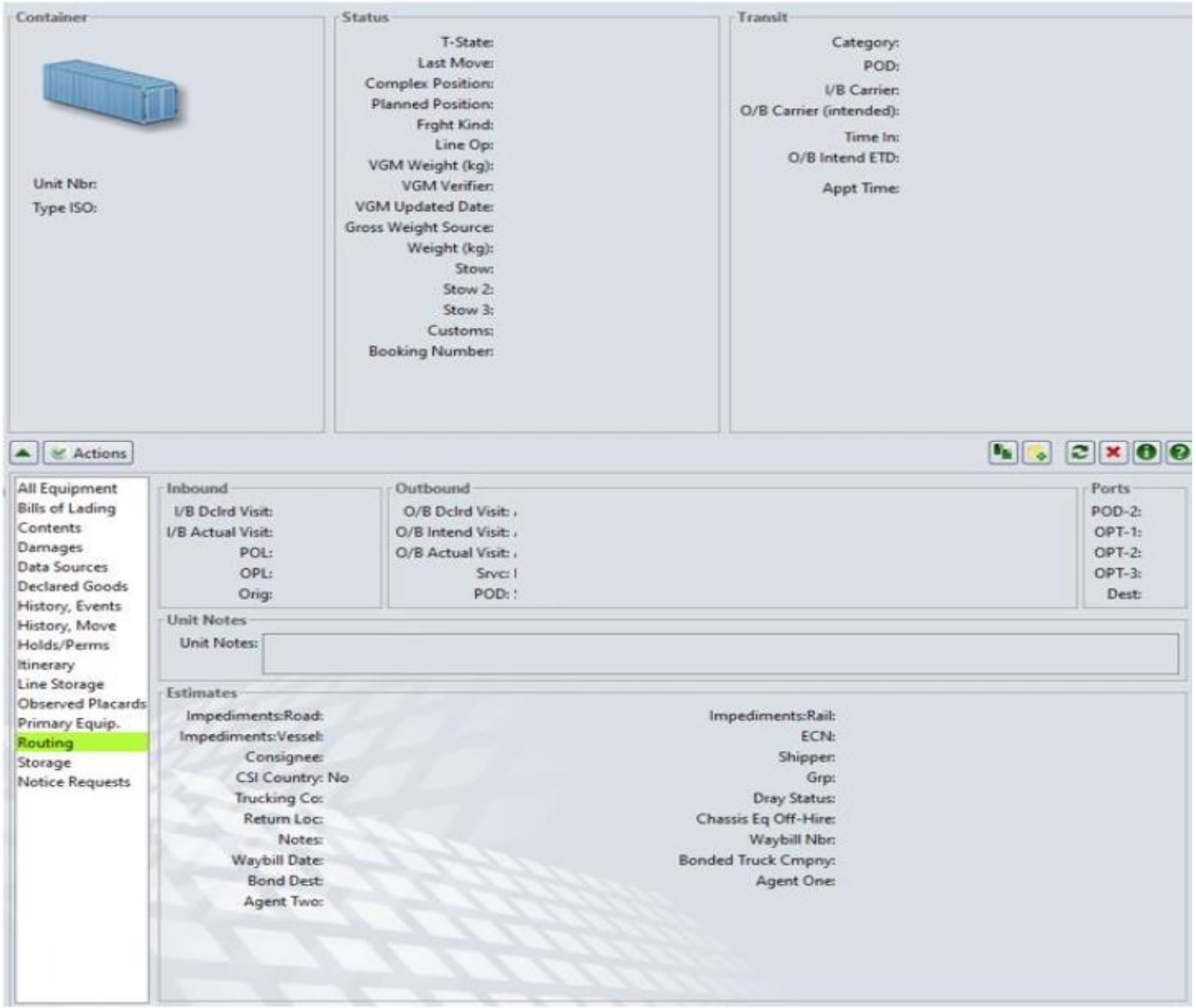
D 3.2. How is the reliability of the operating technology available to perform tasks at Transnet Durban Port?

D 3.3. How is the operating technology affecting current levels of productivity at Transnet Durban Port?

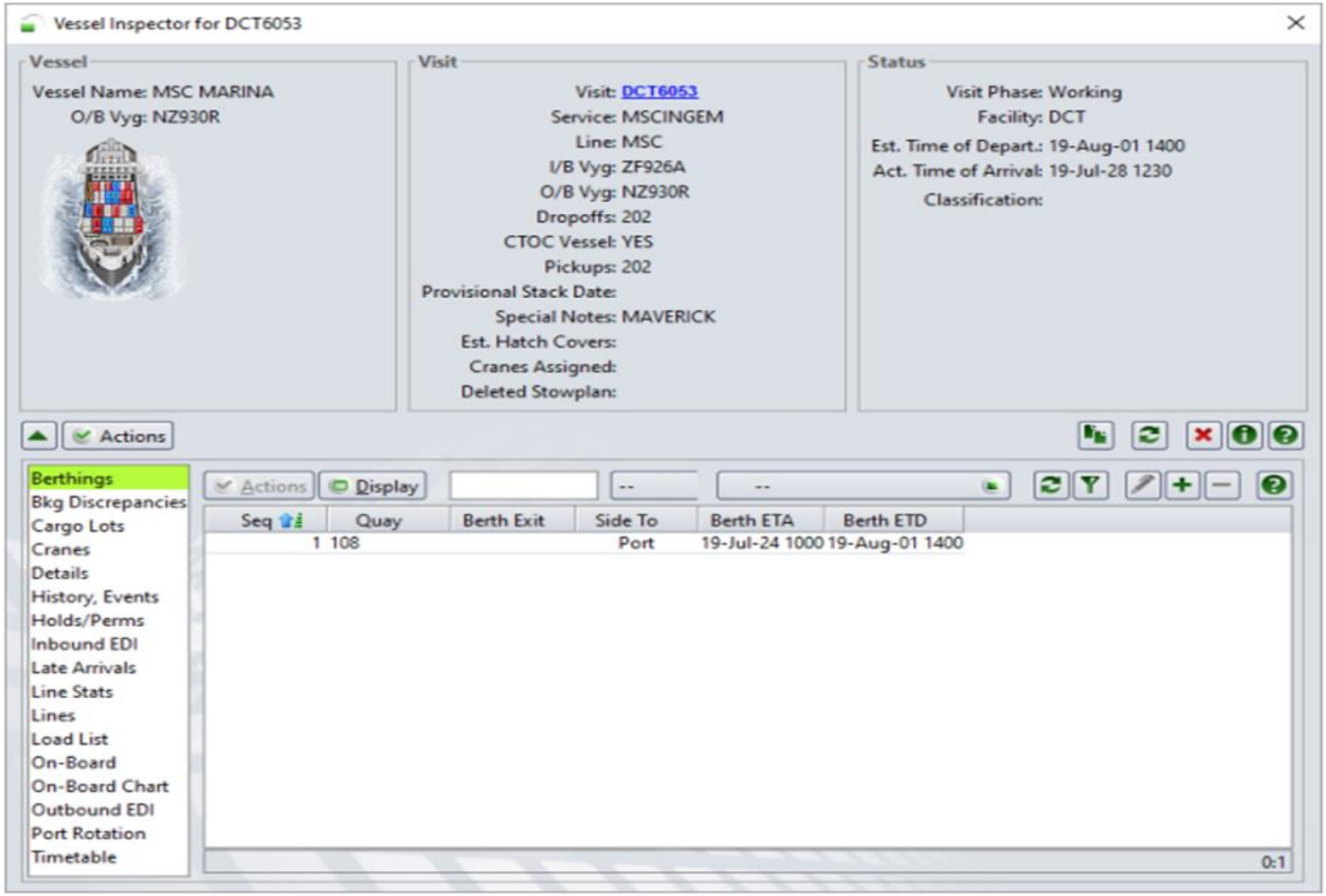
APPENDIX E – DEMOGRAPHICS

Variable	**Category**	**Frequency**	**Percentage**
Age Group	31 – 40	3	30%
	41 – 50	6	60%
	51 – 60	1	10%
Total		**10**	**100%**
Gender	Female	3	30%
	Male	7	70%
Total		**10**	**100%**
Department	ICT	6	60%
	Operations	4	40%
Total		**10**	**100%**
Position	Business analyst	2	20%
	Executive manager	1	10%
	General Manager	2	20%
	Navis Consultant	1	10%
	System Engineer	2	20%
	Terminal manager	2	20%
Total		**10**	**100%**
Employment Status	Contract	1	10%
	Permanent	9	90%
Total		**10**	**100%**
Education	Matric	1	10%
	National Diploma	2	20%
	Undergraduate Degree	4	40%
	Postgraduate	3	30%
Total		**10**	**100%**
Experience at Transnet (Years)	10	1	10%
	12	1	10%
	13	2	20%
	14	1	10%
	16	1	10%
	18	1	10%
	25	1	10%
	26	1	10%
	35	1	10%
Total		**10**	**100%**

APPENDIX G – FIGURE 4.4: CONTAINER ROUTING



APPENDIX H – FIGURE 4.5: BERTH ALLOCATION IN A QUAY



APPENDIX I – FIGURE 5.1: TRANSNET PORT TERMINALS NAVIS TOS JOURNEY