ABERDEEN BUSINESS SCHOOL

Capstone Submission Form

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FOR THE ATTENTION OF	**Dr Raymond Davies/Dr James Cunningham**

Before submitting ensure:

a) that the work undertaken for this assignment is entirely your own and that you have not made use of any unauthorized assistance;
b) that the sources of all reference material have been properly acknowledged.

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Main Word Count in this work --10065

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CHAPTER ONE

INTRODUCTION

Warehousing is fundamental to the supply chain, as it acts as a critical intermediary between consumers and manufacturers, seamlessly flowing goods from the latter to the prior. Effective warehousing operations require perceptive management of complex components to ascertain the timely and accurate distribution of goods. Further, incorporating project management principles can enhance warehouse activities, efficacy, and cost-effectiveness.

Warehousing Elements

Warehousing is centred on the optimization of space. Warehouse managers must carefully design layouts that optimize the existing space to accommodate different products, varying from small and delicate products to large machinery. Using vertical space through shelves and racks optimizes the storage capacity, enhancing businesses' effective inventory management. Therefore, by efficiently managing the available space, warehouse managers can reduce operation costs by streamlining processes and reducing the need for more extensive facilities.

Inventory management is another fundamental warehousing element. Inventory management includes the strategies and processes utilized to monitor, control, and optimize inventory levels in a warehouse. Through stock tracking, inventory levels can be regularly monitored to ascertain the availability of products whenever needed and avoid stock from running out by establishing the minimum stock level at which stock should be replenished. Also, inventory management facilitates categorizing developments concerning demand and value to prioritize management efforts while maintaining a safety stock for future market uncertainties or supply chain disruptions (Jenkins, 2020). Advanced inventory management systems using technologies like RFID tags and barcode scanning improve speed and accuracy when tracking inventory movement. Precise inventory management results in better decision-making since businesses can promptly respond to shifting demands in the market, minimize carrying costs, and optimize reorder points.

Additionally, efficient warehousing depends on streamlined order processing and fulfilment. Businesses must typically incorporate order processing systems with warehouse operations to foster prompt order picking, packing, and shipping. Concerning project management, this integration results in an improved execution of the project. By reflecting on the effectiveness of order fulfilment in project management, the project managers can sustain the project timelines, reducing the risk of holdups.

Another vital element of warehousing is the execution of measures concerning quality control. Commodities in the warehouse must be inspected to ascertain that they meet the set standards. During this process, damaged or defective products are identified and promptly taken care of. The quality control measures ensure that the customers only receive products that meet the required standards.

Besides, modern warehousing operations have incorporated technology for improved effectiveness. Robotics, automation, and data analytics have transformed the warehousing sector. Automated systems accelerate tasks like inventory tracking and order picking, optimizing productivity and reducing human error. Data analytics provides insights into the current inventory trends, enabling businesses to make educated decisions.

Picking process

Aside from the above-mentioned fundamental aspects of warehousing operations, the picking process, another aspect often neglected, is a crucial step in optimizing warehouse operations. The picking process involves handling inventory intending to fulfil specific customer orders. This warehousing aspect has been assessed as the most vital in the supply chain (Viveros et al., 2021), involving at least 52% of all operational costs of warehouse activities. The picking procedure encompasses tasks like seeking, administering, and product transfer, representing 19%, 51%, and 30% of the total order preparation duration.

Travelling is considered an unproductive assignment that adds zero value to warehousing operations. Since it represents the most considerable portion of order times, it presents a chance to enhance warehouse activities. Recently, businesses have aimed to reduce travel times by utilizing technology, including sophisticated storage optimization software, voice-directed picking, and flow racks, expanding 10 – 30% more annually (Bartholdi & Hackman, 2014). This aligns with literature data, estimating that less than 16% of inventory identifiers are positioned accurately. Enhanced options can stem from a more profound examination of the best product placement in a storage facility based on each product's demand.

Product slotting has been recently examined in specialized literature to resolve the challenges of the order-selection procedure. Product slotting addresses order selection by looking for comprehensive product placement in the storage facility (Richardson, 2023). Notably, it is the accurate arrangement of Stock Keeping Units inaccessible storage spaces, determining the storage approach, exact product storage location, and the space volume to be assigned. Product slotting seeks to enhance efficiency in order processing and minimize operations costs.

Various strategies can be utilized to streamline the operations procedure when determining the accurate storage space. However, three major approaches can be distinguished: tiered, dedicated, and random storage. Tiered storage involves classifying, grouping, and storing products in specific slots concerning their turnover rate, facilitating the adjacent assignment of the products that are typically ordered together. A fixed slot for a specific product is assigned in dedicated storage, facilitating quick access to the product in non-automated systems, minimizing the search duration, and enhancing operators' management and relocation of items. Random storage sequentially optimizes the warehouse storage capacity resulting from location-assigning traits, bringing about an evenly distributed allocation.

COMPANY OVERVIEW

SCHLUMBERGER

In the constantly evolving landscape of the global oil and gas sector, one name stands out as an epitome of innovation, proficiency, and unwavering dedication to stretching the parameters of production and exploration. With a legacy spanning nearly a century, Schlumberger has emerged as a pioneering global company well-known for its unequalled contributions towards technological innovation, sustainable energy solutions, and oilfield services. The corporation has steadily reshaped established industry norms, presenting various services facilitating hydrocarbon resources' retrieval, examination, and enhancement from some of the most demanding landscapes globally.

BRIEF HISTORY

Schlumberger's inception can be traced back to 1926, when two inventive French brothers, Marcel and Conrad Schlumberger, made it their mission to transform well logging, officially founding the Schlumberger Well Surveying Corporation. Inspired by their father's work within the geophysics field, they conceived the revolutionary "Schlumberger array," which measured the electrical resistivity of subsurface formations. Their invention emerged as a tremulous shift in exploration techniques (Schlumberger, 2023). This early technological accomplishment illuminated the globe's buried geological secrets and established the groundwork for Schlumberger's unwavering dedication to technological innovation.

Schlumberger's fondness for technological innovation flourished throughout the years. The company scientists and engineers relentlessly worked to craft innovative tools that reinvented exploration standards. Despite all the triumphs, the company experienced its fair share of challenges along the journey of becoming the considerable success it is currently. It exhibited its resilience amidst geopolitical complexities, economic fluctuations, and environmental concerns. Navigating through the oil crisis in the 1970s to the groundbreaking digital revolution of the 21st century, Schlumberger expertly navigated the complex oil and gas sector, becoming one of the industry leaders with unwavering grit.

As environmental and societal awareness rose to prominence, Schlumberger exhibited its dedication to sustainability, reflecting its technological proficiency. The company began its journey to invest in renewable energy research, minimize waste, and reduce its carbon footprint by adopting responsible strategies and eco-friendly initiatives. Moreover, their dedication to societal accountability was demonstrated in various community initiatives, including healthcare projects and educational programs. This complex strategy highlighted Schlumberger's commitment to establishing a perpetual and affirmative influence on the societies it served.

In the company's early years, it exhibited visionary leadership, revolutionary technology, and unwavering dedication to innovation. As the Schlumberger brothers began their mission of transforming the oil and gas sector, their legacy would continue evolving, permanently transforming the energy sector and beyond.

A driving force of sustainability

Central to the company's essence lies a resounding vision, extending beyond sheer company objectives and encompasses the dedication to define and drive high performance sustainably. This vision results from recognizing the complex risks and opportunities of energy evolution and climate change. Schlumberger recognizes the importance of safeguarding nature and people when navigating the energy sector.

Besides, the sustainable warehousing central stores are proof of Schlumberger's commitment to sustainability. This innovative strategy seamlessly incorporates the essential warehousing components, transforming them into a comprehensive approach that reduces environmental impact and optimizes logistical functions.

It is often deemed an integral component, but warehousing entirely shifts concerning Schlumberger's ethos. It materializes as a strategic cornerstone in the operations of the company. Warehousing is an essential element of supply chain management. Effective warehouse management is an essential determinant of a company's resilience and competitiveness in the modern world, defined by globalized trade and increased customer demand. Further, any business operating physical products acknowledges the significance of effective warehouse management, typically regarded as the anchor for successful distribution and sales.

The TVM central stores warehouse is a front-runner in warehousing and industrial supply chain management. The warehouse ascertains that businesses can access the necessary equipment for machinery servicing, repair, and maintenance by operating in the equipment and maintenance industry. It caters to diverse industries such as construction, manufacturing, and energy. Its position in the market is significant as it facilitates uninterrupted operations of the customer's equipment and machinery, which are essential to their business operations.

The primary operations of the warehouse incorporate various critical elements. To begin with, it retrieves, stores, and manages a broad range of components and spare parts, which are necessary for tackling unanticipated machinery breakdowns and routine maintenance. Additionally, the warehouse acts as a distribution hub, ensuring that the correct parts are readily accessible when required by different businesses. Lastly, it provides other services like inventory management, order fulfilment, and effectual warehouse services.

The storage facility is tactically designed to accommodate the varied assortment of parts it handles. Its layout is structured into several sections, each formulated for particular types of parts. This layout facilitates easy access to the parts and reduces the time needed to locate and procure the items. Besides, the facility employs the utilization of the Kardex shuttle’s Vertical Lift Module, an automated storage and retrieval system containing multiple trays that can vertically store parts, optimizing the utilization of the existing space. Using this technology considerably minimizes the need for manual handling, thus reducing the facility's costs associated with labour and reducing the possibility of errors usually caused by humans.

The picking process is central to the storage facility's operations. The ability to procure and swiftly deliver parts to customers differentiates between a costly delay and the smooth running of operations. Enhancing the picking process results in a quicker response rate, increased customer satisfaction, and financial gains.

Problem Statement

Within Schlumberger's manifold operations lies a persistent concern focused on its inventory management and warehousing strategies. During the daily operations of the TVM Central stores warehouse, effective management of service kit components is fundamental in ensuring timely and effective equipment servicing, maintenance, and repair. These kits include several essential parts stored in Kardex Shuttles within a Vertical Lift Module. The kit components are currently distributed across varying trays, resulting in longer travel times, suboptimal picking and packing processes, and inefficient warehouse operations.

To address this challenge and significantly enhance warehouse operations, this project aims to execute a product slotting approach based on the principles of Pareto's law. By identifying and prioritizing the top 20% of the most active and in-demand service kits, the project aims to amalgamate the components of these kits into standard trays within the Kardex Shuttle. Effective warehousing operations are critical for the company's success, given its operations involving oilfield equipment and services. The timely availability of accurate parts for sound services, maintenance, and repairs is fundamental for smooth operations. Solving the challenge of disorganized kits and optimizing the picking process facilitates the reduction of operational costs, improves the company's efficiency, and enhances customer satisfaction.

Literature Review

The supply chain industry is consistently transforming, fueled by the desire for operation optimization and efficiency in productivity. Therefore, efficient warehouse and stock management plays a substantial role in the success of companies, particularly those dealing in the trade of physical commodities. The energy industry, characterized by its multifaceted operations and demanding requirements, is no exception.

Generally, storage facilities have two types of picking systems: parts-to-picker and picker-to-parts (Henn et al., 2012). In the parts-to-picker approach, technological tools like automated systems and conveyors transport products to a central location where the pickers get to retrieve them. This approach minimizes pickers' movement and reduces travel time within the storage facility. In contrast, the picker-to-parts approach involves the pickers travelling to locations where products are stored for retrieval. Also known as the person-to-goods system, this approach facilitates pickers' movement through the warehouse to pick up products for order fulfilment. As per De Koster et al. (2007), at least 79% of order selection across Europe is characterized by the picker–to–parts approach. This project will primarily focus on the picker-to-parts approach since it discusses how the arrangement of products in the warehouse can optimize the picking process, where pickers travel within the warehouse to pick items from their storage location.

The investigation conducted on slotting strategies has been quite diverse. The Cubic per Order Index is among the most common and earliest slotting techniques. The ratio of Stock Keeping Unit cubic volume to the turnover is utilized to organize the Stock Keeping Units in the ascending order of the Cube per Order Index. Other typically utilized strategies for slotting heuristics are product selection frequency, volume, turnover, and popularity (Petersen et al., 2005). The products are rated according to the measure and allocated space in line with the location distance from the input and output points. As the product's rank lowers, the item's location distance increases from the input and output points.

Some storage assignment approaches utilized are across the aisle, within the aisle, golden zone across the aisle, and golden zone within the aisle. Within the aisle, the items are assigned to the pathway closest to the input and output position, and after the pathway is filled, the products are placed in the next closest aisle. On the other hand, across the aisle, the products are placed in the bin nearest to the input and output location in the entire passageway, after which the bins in the next aisle are filled. The golden zone refers to the rack spaces between the picker's shoulders and waist. In both the across and within the aisle, the products must first be placed in the golden zone aisles before getting placed in the two aisles.

A research conducted by Kubasad and Venkatadri (2012) employed within-the-aisle, across-aisle storage arrangement approaches and closest-location heuristics to evaluate the findings, and the two researchers discovered that the nearest-location heuristics offered better results. However, the other approaches also offered good results concerning aggregate distance covered with minimal variation between the tested approaches. Most of the literature on slotting strategies presumes that the selector returns to the input and output location after selecting a Keeping Unit. This is invalid for circumstances where the selector has to pick more than one Keeping Unit to fulfil a customer order. During such circumstances, an affinity-based approach, item correlation, or an order-based slotting approach must be executed where the aggregate distance and duration spent selecting all the Stock Keeping Units for an order are reduced. Besides, the order-oriented slotting approach facilitates the close placement of Stock Units ordered together to reduce the distance travelled and time spent picking the items from their storage location.

Li et al. (2016) conducted a study. They discovered that an item-based affinity and class-based concurrent slotting approach to optimize the aggregate affinity and product of zone pointers and order rate based on ABC grouping offered more optimized order-selection duration reductions than only ABC grouping approaches. An additional strategy under study is order grouping with slotting. Yang et al. (2020) contemplated order grouping with various storage approaches and discovered that storing several Keeping Units in the same space optimized the selection process.

Besides, in a dynamic storage facility, one should consider the effort required to rearrange while planning the slotting approach before re-slotting. This is because picking time enhancements resulting from slotting can rapidly decline in a dynamic storage facility, and regular rearrangement efforts must be implemented (Kofler et al., 2014). It might be impossible to re-slot the entire warehouse periodically. Therefore, only a limited amount of Stock Keeping Units can be rearranged daily, resulting in efficient warehousing operations (Kofler et al., 2011).

Nevertheless, even when the gradual rearrangement of the Stock Keeping Units is undertaken with moves providing the optimal picking efficiency, the resilience of the moves still needs to be contemplated. Some items require daily movement with minimal impact, while others possess less variation with a significant effect on the efficiency of the picking process. Without contemplating the resilience of the priority of moves, it might be time-consuming and costly to re-slot a limited amount of Stock Keeping Units daily. However, in a more extensive study, Kofler et al. (2015) considered the resilience of moves, discovering that an everyday limited slotting approach considers stability and urgency, significant measures that perform better than a thoughtless rearrangement strategy. According to the authors, considering the product's demand during the limited daily re-slotting offers the best outcome.

In this case, slotting the entire storage facility after limited durations is impractical. Therefore, the limited re-slotting of the parts of the kits in the warehouse will be utilized concerning the performance of the storage facility, which will be verified using the Pareto analysis chart. If the performance drops below a specific point, limited re-slotting will be employed to optimize warehousing operations.

An additional aspect affecting the selection duration is the order selection routine. Usually, the objective of routing strategies is sequencing the selection products to reduce the total distance to be travelled. Some systems research the optimized distance. However, heuristic routing strategies are typically utilized due to their ease of implementation and being simple to recall by the selectors. Some examples of the routing problem-solving strategies executed in warehousing activities include S-shape, return, midpoint, and most enormous gap (Rujiter 2007 & Bataineh 2017).

The s-shape approach referred to as transversal, involves the picker entering the pathway from one end and leaving from the opposite end. Therefore, the selector can only move in a single direction within the pathway to cover the required distance. Also, an aisle can only get skipped if the aisle does not contain any products getting picked.

The return strategy enables pickers to enter and leave the pathway from the same point. Therefore, the aisles with items to be picked are the only ones that can be entered or exited. Besides, in the midpoint approach, the picker goes to the central location of the pathway and then returns from the same side, only covering half the aisle. The picker then goes to the remaining half of the pathway to pick any required items.

The most significant gap is similar to the midpoint approach, the sole variation being that the picker goes into the pathway and picks the items to the location where the most significant gap exists among the items to be picked. When this gap is attained, the selector moves to the next aisle to pick the required items by transversing from the adjacent side of the aisle.

While examining efficiency concerning the distance the selector covers for establishing the warehouse slotting strategy can be an excellent primary performance metric, it does not consider the congestion some slotting strategies can bring. While executing storage strategies, congestion should be considered since assigning commonplace items to the exact storage location would result in increased picking time, translating from the waiting duration in congested pathways in multi-picker conditions. While considering congestion, Lee et al. (2020) researched product clustering and storage assignment. According to their findings, congestion can be a source of increased selection time, resulting in slower selection activities. This is particularly common in storage facilities with narrow pathways where multiple pickers cannot travel simultaneously.

Viveros et al. (2021) posited that slotting optimization research has two divisions. The first is designing the process to enhance effectiveness in order preparation, item movement, handling, and other warehouse operations. The second division is linked to model resolution utilizing heuristic algorithms. Various journals have included heuristic and mathematical models for the Storage Location Assignment Problem(SLAP) to address slotting. Some of the articles can be seen in the table below, where approaches established are multifaceted because of the SLAP NP-

Hard complexity. However, most warehouse challenges fall in this category, encouraging the use of heuristics for resolution.

The main aspects of the presented storage location assignment models

Model Aspect	Storage Approach	Optimized function	Solution method
Storage facility with unidirectional crossover passageways	Weight order	Reduce total time travelled.	Mathematical model The C language of programming Basic 6.0 Simulation Microsoft Visual
Linear object movement	Single storage	Reduce the obstructive objects	Genetic algorithm
In line with the principle of shorter periods and lower energy	Random	Reduce storage time and the total energy consumed during the operations	Discrete particle swarm optimization
Storing pallet blocks with storage spaces for a single item.	Random	Reduce aggregate travel distance and optimize the average utility of warehouse storage.	Mathematical model and a productive heuristic system
Machine learning techniques for the problem of Product	Product classification approach comparing with reference picking	Minimizing statistical dispersion pointers and optimizing	Simulation using automatic clustering and feed-forward

allocation	information	clustering quality through the Calinski-Harabasz criterion	artificial neural network
Storing similar traits and WMS integration	First in, first out	Reduce the overall costs	Optimization model Empirical rule
Storage space for a single item	Random	Reduce travel duration and optimize storage utility	Metaheuristic methods: priority rule, random, and genetic algorithm

Certain studies propose decomposing the problem by first addressing the number of locations and then assigning the storage location. Employing this approach, Chen and Lu (2012) tackled the SLAP for outgoing containers in a naval terminus. The authors began by determining the location number from a mixed integer linear programming formulation that clarified the precise storage space concerning a mixed sequence stacking approach. This study illustrated efficiency in comparing and examining performance in the aggregate distance travelled between the bunk and the yard, the disparity of the workload between varying container blocks, and the number of repetitions in loading activities. Thus, the hybrid stacking approach minimizes container movement in cargo activities to 18%, compared to 30% of the average rehandling percentage in the examined case study.

Most published articles consider reducing cost, time, or distance as an objective function. Nevertheless, authors like Ballestin et al. (2017) established a mathematical model that reduces storage time by including a two-objective optimization strategy, optimizing space availability and minimizing production due date measurements. Öztürkoglu (2017) also developed a mathematical model considering two simultaneous objectives: optimizing average storage utilization and minimizing total distance travelled.

Among the primary elements of the SLAP model is the planning horizon. According to studies, examination periods adjusted to the problem were more efficient in correctly arranging the Stock Keeping Units. The approaches offered by the researchers are typically resolved by problem-solving strategies, contemplating the SLAP's convolution. However, these problem-solving models cannot guarantee the solution's optimality, though, at times, they present nearly ideal outcomes depending on the implementation periods and the element set.

Studies have examined the efficiency of varying models for the SLAP. For instance, Gomez et al. (2018) compared an empirical rule and an optimization method. They concluded that the accommodated list's size significantly impacts its system and the idealness of the outcomes. Also, the optimization strategy minimized the cost of labour compared to the solutions offered by metaheuristics. Minimizing costs significantly affects the whole picking process because all operations are interconnected. According to Li et al. (2010), storage location optimization not only minimizes costs and energy consumed during warehousing activities but also enhances the effectiveness of the storage of items. Thus, optimizing the slotting procedure aids in the faster fulfilment of customer orders.

Theoretical Framework

Pareto's Theorem

In management and business, theories illuminate complex issues and offer a structured outline for effective decision-making. The Pareto principle, also called the 80/20 rule, is one such theory that has gone beyond multiple disciplines and applied to different aspects of managerial optimization. This theory, stemming from the works of Vilfredo Pareto, an Italian economist, states that a significant outcome proportion is the result of a small fraction of input. Essentially, around 20% of the existing elements in a process yield 80% of the process results (BetterExplained, 2012). Pareto developed this principle after observing that during the late 1800s, nearly 80% of the land was owned by 20% of the population in his home country. Further investigation revealed that this was the same case in many other countries. The theory gained popularity in the business world during the 1940s after it became apparent that it was an intelligent way to examine business results and decipher where to focus priorities.

Concerning warehousing operations, the theory's core principles are applied to the warehousing activities to optimize the order-picking process. Running a Pareto examination of an operation handling materials is a smart way for a warehouse manager to know what to prioritize, the storage systems to utilize, and the storage locations of the different items. According to the principle, a vital few warehouse items mobilize the most significant share of warehouse activities. Thus, a considerable order percentage, resources, and time are committed to handling the subset of the select items.

The TVM Central stores represent a multifaceted field where multiple components, parts, and tools are accurately stored and retrieved to satisfy the vigorous needs of oilfield activities.

Considering the substantial component diversity and utter volume of the inventory items, it is plausible that some of these items disproportionately contribute to the order-picking process. Therefore, when used as a guiding principle, the Pareto theory facilitates the strategic handling and systematic identification of this minority of high-demand items.

The initial step in applying the theory to Schlumberger's case involves recognizing the high-demand kits responsible for the most significant share of the order-picking operations. This would involve the rigorous examination of historical order information, considering aspects like the quantity demanded, request frequency, and overall contribution to operational amount. With the collected data, the top 20% of kits contributing to 80% of the order-picking process can be easily identified.

After identifying the high-demand kits, the next step would be strategically slotting the components of the kits. The utilization of traditional warehousing strategies has resulted in the components of the kits being randomly distributed across different trays within the Vertical Lift Module of the Kardex Shuttle. This scattered distribution, while at first convenient, ultimately translates to inefficiencies during order picking since the pickers spend valuable time travelling within the warehouse looking for the components, increasing total travel time. This is when the innovative capacity of the product slotting approach facilitated by the Pareto theory becomes apparent.

The order-picking process is optimized by assembling the parts from the kits with high demand in a limited amount of trays. The warehouse operators enjoy reduced travel time and streamlined navigation, considerably enhancing the order-picking process. The reduced travel times result in decreased operational costs and increased worker productivity. The order fulfilment process is also quickened due to the quicker access to parts, increasing customer satisfaction and reinforcing the company's reputation for offering timely services. Further, the proximity of the different parts reduces extensive movement within the warehouse, resulting in minimized wear and tear on the warehouse equipment and saving on energy.

Embracing the Pareto principle as the cornerstone of the product slotting process delivers immediate operational benefits and encourages the business to adopt data-driven decision-making. By analytically examining historical order data and prioritizing high-demand kits, Schlumberger nurtures adaptability, resource optimization, and agility. This reverberates exceptionally well in the energy industry, where efficient resource allocation and receptiveness to customer needs are paramount.

Aim and Objectives of the Study

Main Aim

The primary purpose of this study is to evaluate the optimization of the efficiency of the warehousing operations of Schlumberger's TVM central stores by executing a strategic product slotting approach in line with the Pareto principle.

Specific objectives

i. To identify the high-demand kits within the storage facility's inventory to optimize picking efficiency
ii. To reorganize the arrangement of components within the kits to minimize time wastage
iii. To evaluate the influence of the changes on the efficiency of the order-picking process

CHAPTER TWO

BACKGROUND

As earlier stated, Schlumberger is a multinational corporation with branches in over 120 countries. The company's operations include sound maintenance, reservoir exploration, and drilling. The core of these activities is efficient inventory management, especially in the field of spare parts and tools critical for servicing and maintaining production and drilling equipment. Central to Schlumberger's warehouse operations, the Kardex machine is essential in attaining operational success and optimizing the supply chain process. The Kardex shuttle’s vertical lift module embodies automated storage and retrieval systems, fashioned to streamline warehouse activities and improve the accessibility of fundamental parts.

The Kardex machine works as an essential component in the organization and storage within the warehouse, vertically stacking numerous trays holding an assortment of tools, components, and parts used in thriving services, maintenance, and repair activities. The utilization of the vertical space optimizes the storage capacity. The vertically stored components collectively form kits, which are significant in ascertaining whether the company's equipment is in the best condition before being deployed to working sites and returning from the field. Additionally, these components play a fundamental role in ascertaining that the company's customers encounter minimal interruption during the production and drilling activities. The prompt availability of the right tools at the right time facilitates the company's dedication to offering quality services and enhances customer satisfaction. However, the placement of the components in the trays of the vertical lift module is vital to the overall warehouse efficiency. Inefficient product slotting can result in prolonged travel time, possible interruptions in the flow of operations, and increased picking duration. The management can optimize the storage facility's activities by executing strategic product slotting practices, where items from the high-demand kits are placed together in trays. This simplistic but impactful approach can translate to significant picking time reductions, storage space optimization, and enhanced workflow productivity.

The importance of the Kardex machine becomes apparent when considering the dynamic nature of the oil and gas sector. Unanticipated stoppages and maintenance requirements can interrupt operations, resulting in significant financial losses for the company. Thus, having a well-organized and efficient inventory management system is vital. The Kardex machine optimizes storage space and facilitates the picking process's acceleration. Parts that are easy to access and organized logically can be swiftly retrieved, reducing downtime in case of a breakdown or maintenance of the downhole and measurement equipment.

Moreover, the Kardex machine intersects with extensive supply chain approaches, impacting the overall operational effectiveness of the company. By employing the machine in its operations, Schlumberger can ascertain that the correct parts are availed at its central stores, enabling swift dispatch and delivery to field locations. This facilitates optimal resource allocation for the company while also improving its brand reputation concerning reliability. The Kardex machine represents the company's commitment to innovation and efficiency. It signifies Schlumberger's adaptability to technological developments and dedication to delivering outstanding customer quality.

Scope of work

This capstone project focuses on improving the kit sorting process within Schlumberger's warehouse operations. Remarkably, there will be a focus on enhancing the efficiency of assembling kits with various parts needed for sound services, maintenance, and repairs of the drilling and measurement equipment. There will be an emphasis on identifying the highly demanded kits by applying Pareto's theory and re-slotting the parts in the vertical lift module of the Kardex shuttle to maximize the picking process efficiency.

While the entire storage facility is significant, the primary objective of this capstone project is the kit sorting process and the placement of parts in the Kardex shuttle. This incorporates understanding the current arrangement of parts in the shuttle, examining historical order data to establish the high-demand kits, reorganizing trays to accommodate the kits, and determining the effect of these modifications on the picking period length and the general work optimization.

Although the project mainly intended to optimize the kit sorting process, some warehousing elements fell beyond the scope. For instance, other warehousing activities like order fulfilment and the extensive warehouse management system were excluded. Also, the project did not incorporate developing or modifying specific software or tools.

The study was conducted at my placement organization, Schlumberger, an international front-runner in the oil and gas sector. The project timeline was divided into three phases: data collection, analysis and optimization, and implementation and evaluation. The data collection phase involved collecting relevant data, such as order frequencies, historical picking times, and tray locations for different kits. The data collected provided information regarding the most frequently picked kits and the corresponding components required to be rearranged in the Kardex shuttle.

Following the data collection phase, the analysis and optimization stage facilitated a thorough, comprehensive analysis applying Pareto’s principle and identifying the topmost kits with the highest demand. Further, there was a modification in the arrangement of parts in the trays of the Kardex shuttle to optimize the process of picking the kits. Optimization techniques were used to test different tray arrangements to identify the most efficient layout. The final phase was implementing and evaluating the optimized tray arrangement. The parts of high-demand kits were rearranged in the Kardex shuttle according to the new optimized layout. The picking [periods and workflow optimization were monitored closely to evaluate the effect of the modification performed.

Thus, through an elaborate scope, the project's purpose is to optimize the picking process, enhance workflow, and facilitate the general operational effectiveness of the warehouse system.

Models and Theories

1. Pareto's principle

Pareto's theory, developed by economist Vilfredo Pareto, posits that a small portion of causes drives substantial effects. Concerning the project, Pareto's theory would facilitate pinpointing the top 20% of kits, contributing to an 80% estimate of the total orders. This would only be possible after examining historical order patterns data. Besides, identifying the high-demand kits is a strategic imperative to optimize operations, improve warehouse efficiency, and effectively allocate resources.

Some kits require more attention than the rest during the kit sorting process. Pareto's principle can guide resource allocation for maximum impact. Thus, by concentrating efforts on the top 20% of high-demand kits, resources like labour, time, and technology will be efficiently allocated, yielding significant returns in warehouse activities. Pareto's theory reinforces strategic efficiency, a concept in which resources are intellectually invested to resolve the most noteworthy pain points.

Besides, by aiming for high-demand kits, the storage facility gains a competitive advantage by confronting the leading causes of inefficiencies and delays. By repositioning the parts on the Kardex shuttle trays, frequently requested parts are promptly available and easily accessible, translating to a faster picking time for the warehouse operators and a smoother workflow.

Further, this tactical optimization corresponds with comprehensive supply chain aims. By restructuring the kit sorting process for highly demanded components, the supply chain enjoys minimized lead times, enhanced client satisfaction, and increased responsiveness. The ensuing enhancements flow throughout the warehouse operations, resulting in a highly efficient facility.

2. Lean Six Sigma

This robust methodology assimilates the principles of lean and Six Sigma to enhance processes, reduce wastage, and enhance efficiency in different industries (Boehler, 2021). Concerning optimizing the kit sorting process of the Kardex Shuttle system, this methodology provides a planned and logical approach to optimize operations, establish inefficiencies, and maximize resource utilization.

Optimizing the kit sorting process at the warehouse seamlessly corresponds with the Lean Six Sigma principles. This is because both strategies underscore quality enhancement, waste reduction, and general improvement in efficiency. The methodology provides a framework that perfectly aligns with the study objectives: to change part placements in the Kardex shuttle system to accelerate order picking and minimize time spent searching for the parts.

The core of the Lean Six Sigma methodology is centred on making data-based decisions. This is especially significant to this study, where pinpointing the most demanded kits is vital for optimization efforts. The lean Six Sigma methodology enables us to accurately pinpoint the top 20% of kits that bring about the most orders by analyzing historical data linked to the use of the kits, picking frequency, and the trends in demand. This examination corresponds with the principles of Pareto's theory, where a small number of kits are liable for a substantial portion of demand.

Besides, Lean Six Sigma assists in recognizing high-impact areas and also allocating resources and efforts for optimal results. The 80/20 principle, integral in the approach, corresponds with the belief that a significant portion of the outcome results from a small portion of the input. By identifying that all kits require different amounts of attention, the study is placed in a position where it has to prioritize high-demand kits, subsequently maximizing returns on investments in resource utilization and efficiency gains. Concerning Schlumberger, the lean Six Sigma approach supports allocating resources, time, and efforts to optimize the part placements in the Kardex shuttle trays for the high-demand identified kits. This calculated allocation reduces the risk of over-optimizing kits with low demand, ascertaining that efforts are channelled where they are most required and impactful. This principle directly corresponds with the Lean principle of avoiding wastage, in this case, the wasteful allocation of resources to kits with low demand, hence low returns.

At the centre of the Lean Six Sigma approach is the DMAIC (Define, Measure, Analyze, Improve, Control) framework, a systematic approach that guides projects from beginning to completion while ensuring the decisions made at each stage are well-informed and backed up by existing data. The first step is clearly defining the existing problem and project objectives. In our case, this would involve comprehending the inefficiencies in the current part placement process and setting a well-defined objective of optimizing the kit-sorting process by prioritizing the high-demand kits and rearranging the kit parts in the Kardex shuttle tray to optimize the entire picking process. The following two steps, measure and analyze, go hand in hand. The measure is characterized by collecting relevant data to quantify the problem's extent. Therefore, past data on kit usage, demand patterns, and picking times should be collected and carefully analyzed to establish the top 20% of kits in high demand. This would facilitate the efficient allocation of resources to optimize the entire warehousing operations. Analyzing the data is also purposed to identify the root of the picking process inefficiencies and comprehend the factors contributing to the prominence of the kits with the highest demand.

After data analysis and recording the findings, solutions to the discovered inefficiencies are developed and implemented in the improvement stage. Therefore, the parts of the kits are reorganized within the Kardex shuttle trays, with the parts belonging to the high-demand kits receiving the top priority and being placed in trays that are easily accessible. This enhancement is sustained by executing control and monitoring mechanisms such as tracking the picking times and order fulfilment rates to observe the impact of the developed solution.

Therefore, through its principles of proper resource allocation, waste reduction, and decision-making backed up by existing data, the lean Six Sigma approach seamlessly corresponds with the objectives of this study. By identifying high-demand kits, effectively prioritizing resources, and employing the DMAIC approach, the lean Six Sigma strategy drives the project toward enhanced efficiency, reduced waste, and a streamlined workflow, resonating with Schlumberger's dedication to providing operational excellence.

3. Just-In-Time (JIT) Inventory Management

The JIT inventory management is a philosophy highlighting the delivery of components, materials, or items exactly when they are required for distribution or production, not a moment later or sooner (Stevens, 2022). Based on the Toyota Production System and lean manufacturing principles, JIT's purpose is to eradicate waste, reduce the carrying costs of the inventory and synchronize supply with demand, thus improving the efficiency of the processes.

Concerning this research, the first step in applying the JIT principle is identifying the high-demand kits that are most active. This principle offers a systematic approach for prioritizing efforts and resources to optimize kit sorting and reduce wastage. By prioritizing the high-demand kits that are most active, the resources allotted to inventory storage, picking, and packing are focused on the kits with a direct effect on client satisfaction and operational productivity. This efficient assignment of resources prevents resources from being tied up in surplus inventory that might take some time before being utilized.

Some merits of employing the JIT philosophy include; minimized dead inventory, reduced inventory holding costs, minimized lead time, and enhanced picking efficiency. JIT ensures that the existing inventory corresponds with customer demand, preventing the accrual of items with low demand in the storage facility. This, in turn, saves warehouse costs linked to the storage and maintenance of surplus inventory with low returns. Also, the JIT principle facilitates the strategic placement of high-demand kits in the Kardex shuttle system for prompt access when required, streamlining the order-picking process, which translates to reduced search efforts and travel times, and the enhancement of eventual customer satisfaction.

Hence, applying the JIT inventory management principle is a systematic effort that seamlessly corresponds with Schlumberger's pursuit of operational success. The philosophy's emphasis on reducing resource wastage, balancing the demand with the supply, and efficiently allotting the resources directly addresses the kit sorting process's inefficiencies. Schlumberger can optimize its operations, enhance efficiency, and minimize operational costs by pinpointing the most active high-demand kits and tactfully placing them on the Kardex shuttle trays. The JIT philosophy embodies a comprehensive approach to inventory management, which corresponds with the storage facility's optimization objectives and unrivalled customer service.

4. <u>Lewin’s change management model</u>

According to the model developed during the 1940s by psychologist Kurt Lewis, organizational transformation encompasses unfreezing, transitioning, and refreezing. This model is highlighted by the conviction that change involves modifying attitudes, behaviour, and mindset, requiring a premeditated approach to facilitate a seamless transition (Hussain et al., 2018).

The enhancement of the kit sorting process at Schlumberger involves a noteworthy alteration to how parts are stored and retrieved. Applying Lewin’s management model to this optimization offers a holistic framework for addressing resistance, enabling adaptation, and eventually ascertaining the successful execution of the optimized process.

The unfreezing phase creates an awareness of the need for change and a sense of urgency. This stage aligns with the kit sorting optimization process by identifying the inefficiencies in the preexisting process and communicating the reasoning behind the need for the transformation. Using Pareto's principle, the company can quickly identify the most active high-demand kits with the most significant effect on the general workflow efficiency. By associating the pinpointed high-demand kits with the company's performance metrics, the company can highlight how the sorting process inefficiencies directly affect customer satisfaction and rates of order fulfilment. Hence, a transparent need for change is established.

The next phase, transitioning, involves implementing the transition and managing its challenges. Thus, the parts of the kits are reorganized in the Kardex shuttle system trays for their correspondence with the ranked high-demand kits. Lewin's model underscores the significance of involving workers in the change process. Involving the warehouse operators in charge of the kit sorting process in the decision-making process of rearranging the parts would minimize potential resistance. Besides, the operators would provide their insights into the practical effects of part placements, improving the efficiency of the optimized approach.

The final stage, refreezing, seeks to stabilize and maintain the transformation. Thus, the adopted optimized kit sorting process is cemented and constantly evaluated to ascertain its sustainability. The enhanced efficiency and reduced kit-picking time prove the merits of the undertaken change. This fortification solidifies the parts placement change as the new standard operating system.

Therefore, Lewin's change management model enables Schlumberger to communicate the need for change effectively, involve stakeholders, and systemize the optimized process. Pareto's principle facilitates the application of this model by providing a logical approach to prioritizing efforts and resources for optimal effect. Through this holistic approach, optimizing the kit sorting process advances the company toward operational excellence, ensuring a smooth transition and sustainable change in the warehousing activities of the central stores.

Industry Trends and Challenges

Technology has become central to transforming warehouse operations in recent years. Robotics, automation, and data analytics are transforming the traditional approaches to warehousing. Contemporary warehouses incorporate advanced automated storage and retrieval systems to improve accuracy and effectiveness. The technology-driven innovations are revolutionizing inventory management, driving businesses to look for solutions that streamline operations and minimize operational costs. Therefore, by implementing the product slotting strategy to optimize the kit sorting process, the study corresponds with the wave of technological improvements within the industry. The digital revolution of warehouses highlights the study's practical relevance and symbiotic relationship with tech-driven trends.

Today, customers have gotten used to the convenience of e-commerce, expecting their orders to be promptly and accurately fulfilled. This modification in client expectations has obligated businesses to restructure their storage strategies. Swift and accurate order processing has become a necessity. Thus, warehousing activities must adapt to these amplified client expectations to remain relevant to clients and meet the competition in the industry. In this project's context, the optimization strategy's implementation aligns with changing client expectations. Ascertaining the availability of the high-demand kits corresponds with the expectation of prompt order fulfilment. By reducing retrieval durations, improving picking accuracy, and optimizing the entire warehouse operations and overall workflow, the study contributes to meeting the customer's changing demands.

Additionally, the modern business world is typified by fierce competition, with each business looking for a competitive edge. In such a landscape, agility, efficiency, and cost-effectiveness are imperative, and warehouses are no exception. Their operations must be optimized to reduce waste, minimize delays, and maximize the use of existing resources. Executing the kit sorting strategy would give the storage facility a competitive edge over other warehouses if it were to be leveraged. The resulting efficiency from the strategy would enhance competitiveness and position Schlumberger as a reliable partner in the intensely competitive industry.

The spread of data collection and analysis tools has revolutionized typical business operations. The practical application of data during decision-making has become the backbone of supply chain management. Companies utilize data analytics to project demand, identify trends, and enhance inventory levels. Concerning the kit sorting strategy, past warehouse records can be used to pinpoint high-demand kits and tactically position their components to enhance the efficiency of warehouse operations. This data-controlled strategy ascertains proper resource allocation, facilitating the optimization of warehouse operations.

Further, the proliferation of environmental consciousness has made sustainability the top priority among other business strategies. Consumers are enhancing their awareness of their purchases' effect on the environment, and businesses are responding by implementing green practices. This includes optimizing transport passageways, minimizing the energy consumed, and reducing the waste of available resources. Thus, implementing the kit sorting process would contribute to sustainability efforts and improve warehouse operations' efficiency. The study corresponds with the industry's push toward environmentally-conscious operations by enhancing the picking accuracy and reducing the travel time in the warehouse for item retrieval.

CHAPTER THREE

METHODOLOGIES

This chapter will explore the methodologies used to deal with the warehouse inefficiency problem discussed in the previous chapters. This chapter is significant in determining the integrity and accuracy of the study. It outlines the steps taken to collect, analyze, and interpret data, ascertaining the credibility and accuracy of the findings.

Research Approach and Methods

For this capstone project, the selected research approach is mainly empirical, incorporating data collection and analysis. The empirical approach is best suited to tackle the practical challenges Schlumberger's warehouse activities encounter. It corresponds with the study's objectives to optimize parts placements in the Kardex machine system trays. This approach will involve collecting and analyzing practical data to develop insights and make well-versed decisions. Besides, the research approach seeks to offer a holistic understanding of the current activities of the storage facility, pinpoint the most active high-demand kits, and propose an optimized product slotting approach. The primary data collection methods were observation, consultation with warehouse personnel, and historical data analysis.

Data collection

i. Observation

I directly observed the facility's daily operational activities, identified physical constraints, and developed insights into how the kits were stored and picked. This data collection approach offered a real-time understanding of the operational inefficiency the facility was undergoing. Further, by observing, I could measure the time it took to pick kits before the rearrangement of the parts in the kits and after the parts placement optimization to examine the effectiveness of the proposed strategy.

ii. Consultation with other employees

While working at my placement organization, I interacted with other workers at different levels, including operators, managers, and supervisors. During these interactions, I consulted with them to gain a deeper understanding of the existing process, and they shared their varied perspectives, including the process inefficiencies and possible areas that can be enhanced. This approach facilitated a better understanding of the high-demand kits and how frequently they were used. By involving other employees who are intricately conversant with the daily operations at the facility, the collected data can be cross-verified and enhanced with qualitative perceptions.

iii. Historical Data review

This step incorporated collecting past data on the order-picking periods, inventory movement patterns, and kit-sorting periods. The secondary data was retrieved from the warehouse management system and was employed in determining the trends and seasonal variations, blockages, and inefficiencies in the existing process.

Data analysis

The Pareto analysis was employed to identify the top 20% of most active high-demand kits that significantly contributed to the order-picking operations. The approach hoped to attain an optimal effect on efficiency enhancements by focusing on these kits. Statistical techniques were employed to quantify the frequency of kit usage and associated picking times. Further, data visualization in graphs was used to represent the analysis results visually.

Product slotting strategy

Concerning the insights gained from the data collected and the data analysis, a product slotting strategy was developed to optimize the placement of the kit components, thus enhancing the efficiency of the operations. The strategy facilitated grouping high-demand kits near, reducing picking time and minimizing travel time.

Implementation plan

The execution plan for the product slotting strategy involved kit categorization, tray allocation, and physical rearrangement. Informed by records and operational insights, high-demand kits were ranked in line with their components and usage frequency. The kits in the same category were placed in the same tray on the Kardex shuttle system to ensure that frequently picked items were easily accessible, thus reducing picking time. The physical reorganization of kits in the Kardex shuttle was conducted in alignment with the operators in the facility.

Validation and testing

Before executing the product slotting approach, we conducted a testing and validation phase on a sub-set of high-demand kits. We implemented the proposed changes on the subset and closely monitored the effect on order picking efficiency and time spent sorting. The necessary adjustments to the product slotting strategy were made in line with the observations made during this testing phase.

Ethical considerations

Ethical considerations were vital in working with the company's data throughout the research process. I ensured to obtain permission from the company to access records and observe the facility operations. Consultations with the other employees were voluntary, and their identities were kept confidential in the study report. The study aimed to improve the company's operational efficiency, thus benefiting it, and any possible disruptions to the operational activities that this research could have caused were minimized.

Hence, the methodologies used during this research offered a holistic and structured approach to tackling the inefficiencies in sorting the kits. The study purposed to deliver actionable recommendations to enhance warehouse efficiency by integrating quantitative data analysis, qualitative insights from consultations with other employees and personal observations conducted, and a systematic product slotting strategy.

CHAPTER FOUR

In modern supply chain management, a warehouse's effective and efficient operation is the backbone for operational success. Accurate and timely order fulfilment depends on the smooth alignment of several factors in the storage facility, and among these fundamental factors is product slotting. In our case, the fundamental element is sorting the parts within the kits, prioritizing kits on high demand. Picking and packing items from the inventory directly impacts operational efficiency, consumer satisfaction, and energy consumption. This chapter will analyze the transformative effects of executing a product slotting strategy to optimize the sorting process in a storage facility.

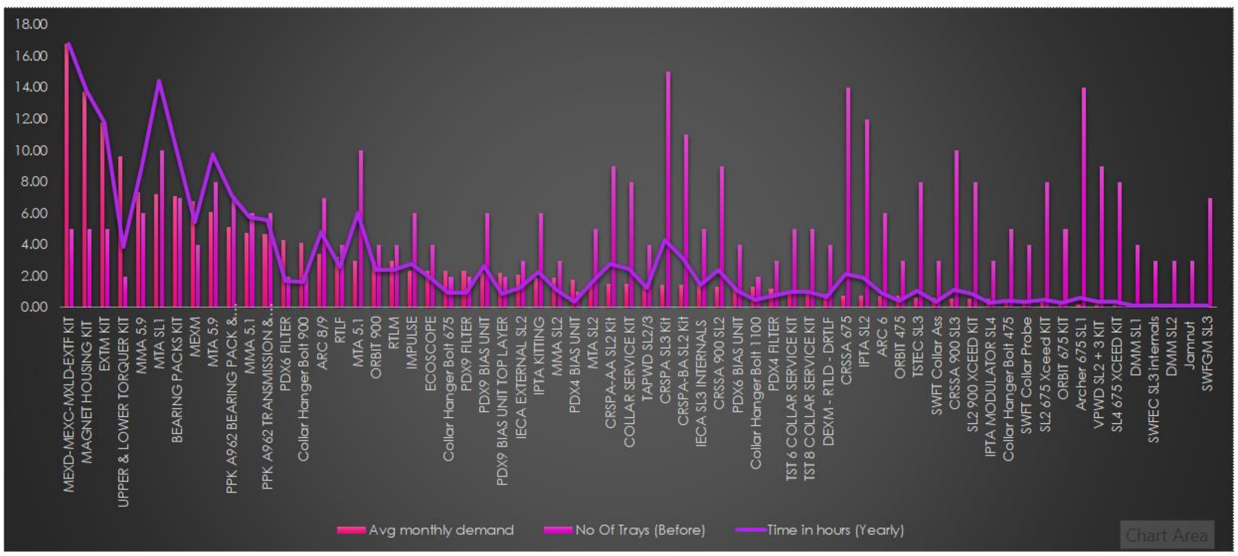
Context

A storage facility employed a Kardex shuttle's vertical lift module to store and retrieve parts from trays for various kits. Before the slotting strategy was optimized, parts within the kits were dispersed across different trays, translating to longer durations spent sorting the parts, inefficient route planning, and increased energy consumed by the Kardex shuttle during operations. The primary aim was to tie together the principles of product slotting, where kits with the highest demand would be placed close to each other, thus minimizing the time spent retrieving the parts from different trays in the system and improving the general efficiency.

Reflective accomplishment

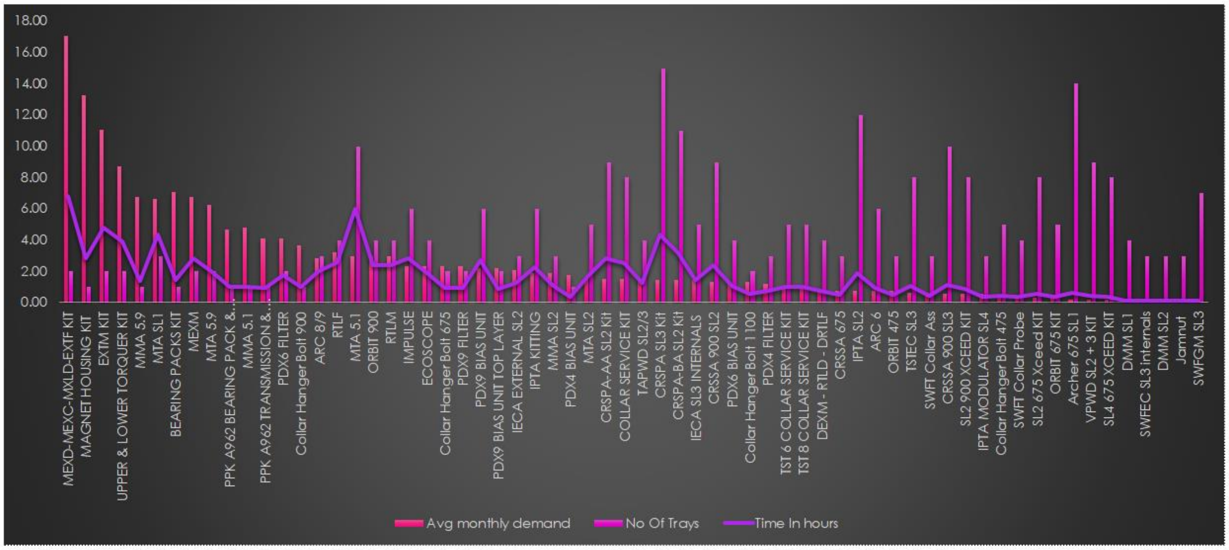
A holistic Pareto analysis of before and after data was conducted to evaluate the impact of the product slotting strategy. Different kits with different average monthly demands were selected for analysis. The number of trays necessary for storage before and after optimization was recorded for every kit. Also, the amount of time taken to sort the parts in each kit was measured before and after the execution of the optimization of the slotting strategy. All this data was collected and recorded yearly to ascertain a comprehensive analysis.

Pareto Chart Analysis - Before



Graph representing the Pareto Analysis before the implementation of the product slotting strategy.

Pareto Chart Analysis- After

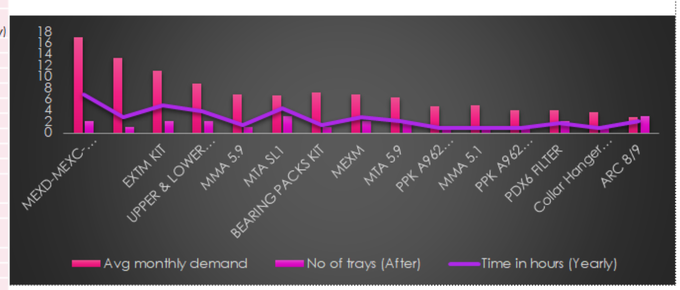


Visual representation of the Pareto analysis after implementing the product slotting strategy.

Before and After- Comparison

Kit	Avg monthly demand	No of trays (Before)	Time in hours (Yearly)
MEXD-MEXC-MXLD-EXTF KIT	17	5	17
MAGNET HOUSING KIT	13	5	14
EXTM KIT	11	5	12
UPPER & LOWER TORQUER KIT	9	2	4
MMA 5.9	7	6	9
MTA SL1	7	10	14
BEARING PACKS KIT	7	7	10
MEXM	7	4	5
MTA 5.9	6	8	10
PPK A962 BEARING PACK & ADJUSTABLE SECTION	5	7	7
MMA 5.1	5	6	6
PPK A962 TRANSMISSION & MOTOR CATCHER	4	6	6
PDX6 FILTER	4	2	2
Collar Hanger Bolt 900	4	2	2
ARC 8/9	3	7	5

Kit	Avg monthly demand	No of trays (After)	Time in hours (Yearly)
MEXD-MEXC-MXLD-EXTF KIT	17	2	7
MAGNET HOUSING KIT	13	1	3
EXTM KIT	11	2	5
UPPER & LOWER TORQUER KIT	9	2	4
MMA 5.9	7	1	1
MTA SL1	7	3	4
BEARING PACKS KIT	7	1	1
MEXM	7	2	3
MTA 5.9	6	2	2
PPK A962 BEARING PACK & ADJUSTABLE SECTION	5	1	1
MMA 5.1	5	1	1
PPK A962 TRANSMISSION & MOTOR CATCHER	4	1	1
PDX6 FILTER	4	2	2
Collar Hanger Bolt 900	4	1	1
ARC 8/9	3	3	2



Visual aid comparing the before and after implementing the product slotting strategy.

Kit	**Average monthly demand**	**Number of trays before**	**Time in hours(yearly, before)**	**Number of trays after**	**Time in hours(yearly, after)**
MEXD-MEXC-MXLD-EXTF KIT	17	5	17	2	7
MAGNET HOUSING KIT	13	5	14	1	3
EXTM KIT	11	5	12	2	5
UPPER AND LOWER TORQUER KIT	9	2	4	2	4
MMA 5.9	7	6	9	1	1
MTA SL1	7	10	14	3	4
BEARING PACKS KIT	7	7	10	1	1
MEXM	7	4	5	2	3
MTA 5.9	6	8	10	2	2
PPK A962 BEARING PACK & ADJUSTABLE SECTION	5	7	7	1	1

MMA 5.1	5	6	6	1	1
PPK A962 TRANSMISSION & MOTOR CATCHER	4	6	6	1	1
PDX6 FILTER	4	2	2	2	2
Collar Hanger Bolt 900	4	2	2	1	1
ARC 8/9	3	7	5	3	2

Concerning the graphs above and the summary of the table comparing the before and after the implementation of the product slotting strategy, the most noticeable outcome of the strategy was the dramatic reduction in sorting duration. Before the implementation of the strategy, the total time spent sorting the parts for the top 20% highest demanded kits was an average of 121 hours yearly. However, after implementing the strategy and optimizing the warehouse operations, the time was significantly reduced to around 38 hours a year. This represents an incredible 31% reduction in the average route duration for the top 20% of highly demanded kits. This reduction enhanced operational efficiency since less time was spent searching for and retrieving kit parts, thus facilitating prompt order fulfilment.

Additionally, some kits underwent significant improvements due to the optimization strategy. Remarkably, the "MEXD-MEXC-MXLD-EXTF" kit exhibited a considerable change. Before implementing the product slotting strategy, the kit needed 17 hours yearly to sort parts across five trays. However, after the implementation of the strategy, the time needed to sort the parts was reduced to 7 hours after the parts were rearranged into only two trays. This trend was witnessed across other kits, indicating the strategy's effectiveness in optimizing efficiency.

The advantages of reduced sorting periods are extensive. The general operational efficiency of the warehouse was significantly boosted since the streamlined sorting process resulted in more prompt retrieval of items and fulfilment of orders. As a result, customer satisfaction was positively affected due to the swift processing of their orders, meeting their expectations. The accuracy of the picking process was enhanced, further improving the customer's experience with the company.

Transcending operational efficiency, the optimization strategy contributed to energy efficiency in the storage facility. The operational time of the Kardex machine was minimized because of the faster retrieval of parts, saving some energy that would have been otherwise wasted before the optimization strategy was executed. This corresponds with Schlumberger's sustainability objective since minimizing energy consumption cuts operational costs and minimizes warehouse operations' carbon footprint.

Conclusion

Aligning with this study's primary aim and specific objectives, the execution of a strategic product slotting approach in the storage facility of Schlumberger has resulted in significant and impactful enhancements in the effectiveness of warehouse activities. By applying the Pareto principle, the project aimed to reorganize the kit arrangements, optimize the picking efficiency, and analyze the subsequent impact on the order-picking activity. The findings and results of this examination highlight the success of these aims and offer valuable insights into the progressive changes attained.

Identification of the top highly-demanded kits

Among the specific aims of this study was to identify the top 20% of the highly demanded kits in the warehouse. Applying the Pareto theory, the top 20% of high-demand kits were targeted. The Pareto analysis results indicated that the MAGNET HOUSING KIT, EXTM KIT, and MEXD-MEXC-MXLD-EXTF KIT significantly improved sorting times and efficiency after executing the product slotting strategy. This consequence authenticates the effectiveness of identifying high-demand kits and emphasizes the significance of targeting these kits for enhanced efficiency.

Reorganizing kit arrangements

Reorganizing the parts within the kits was critical in reducing the time wasted during the sorting process. By implementing the optimization strategy, the arrangement of the components was optimized to ascertain that the top kits with high demand were kept close. This resulted in a significant reduction in the time spent sorting the kits, enhancing operational efficiency.

The efficiency of the order-picking activity

The last specific objective was to examine the effect of these changes on the effectiveness of the order-picking process. The data demonstrates the success of the optimized strategy in improving the order-picking activity. Average route durations for the top highly demanded kits were minimized by 31%, translating to parts retrieval and enhanced accuracy in putting together the parts of a kit. These enhancements led to a more streamlined order fulfilment process and optimized warehouse operations.

Therefore, the study's findings correspond with the initial problem statement and the specific aims. The main objective was to enhance the efficiency of warehouse activities, and the attained results indisputably validate this aim. The improvements in route durations, sorting periods, and general efficiency showcase the success of the implemented optimization strategy. By prioritizing highly demanded kits and reorganizing the placement of the kit components, the study has tackled the challenges of an inefficient sorting process.

Recommendations

The warehouse operators and company management should regularly examine the kits' demands and usage patterns. By keeping up with changes in demand, Schlumberger can modify the kit arrangements and tray placements accordingly. This will facilitate the maintenance of the product slotting strategy over time, maintaining high levels of efficiency and preventing possible disruptions.

Schlumberger should conduct training sessions where the workers are familiarized with the principles and merits of the optimization strategy. Also, encouraging open communication from the employees about possible operational enhancement opportunities or challenges nurtures an engagement culture, inspiring continuous improvement. Employee insights can result in innovative changes that underscore the efficiency of the strategy.

Restructuring the arrangement of kit components enhances operational efficiency and minimizes excessive energy consumption. Schlumberger can thus align its efficiency objectives with broader sustainability objectives by quantifying the energy savings from implementing the optimization strategy, which would appeal to environmentally conscious stakeholders.

Limitations

To begin with, this study's results depend on a specific set of conditions that might only apply to some warehouses. Different products, industries, and operational dynamics can result in different outcomes.

The study was conducted in a specific time frame, which might have yet to adequately capture the long-term trends in customer demand. A more prolonged study period offered a more comprehensive understanding of the strategy's effectiveness and sustainability over time. Also, external factors transcending the scope of the study, such as industry changes or economic shifts, could affect the accuracy of the findings and the rationality of executing the product slotting strategy in varying settings.

Further, the study mainly focused on the picking process of warehousing operations and the optimization of its efficiency, yet other elements of warehouse activities, such as order fulfilment, needed to be more extensively covered. Thus, future studies should examine these aspects extensively to provide a more holistic understanding of the general warehouse operations.

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