MANAGEMENT AND CONTROL OF INVENTORY: THE CASE STUDY OF A SOUTH AFRICAN COMPANY

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DECLARATION

I Sipho Ngunyule, hereby declare that the dissertation “Management and Control of Inventory” submitted for the Magister Of Philosophy (MPhil): Engineering Management degree, Faculty of Engineering and Built Environment at the University of Johannesburg, apart from the recognised assistance, is my own work and has not previously been submitted to another university or institution of higher education for a degree.

ABSTRACT

Costs associated with backlog and significant inventories affect the company's profit. An inventory is a crucial aspect in controlling and reducing supply chain costs and improving customer satisfaction. Predicting inventory is difficult due to the number of dependences which need to be satisfied like customer demand, production plans and procurement policies. This study aims to identify the causes of high inventory levels at case study company and suggest ways to manage and control inventory levels. The study used quantitative and qualitative methods to collect the evidence required to answer the research questions. Data were also collected from the questionnaire and document reviews. Tools, such as a cause and effect diagram, trend analysis and histograms, were employed to analyse data and causes of the inventory levels. Results indicate that deficient planning of sales, early purchases of materials, early delivering of materials, inventory inaccuracy, high work-in-process and deficient coordination, are causes for high inventory levels. Case study company management is recommended to align the three plans, namely: sales plan, purchase plan and inventory plan.

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ABBREVIATIONS

ANN	Artificial Neural N*et*works
BN	Billion
BOM	Bill of Materials
CEO	Chief Executive Officer
COS	Cost of Sale
CR	Change Request
EDI	Electronic Data Interchange
EOQ	Economic Order Quantity
ERP	Enterprise Resource Planning
EXCO	Executive Committee
HR	Human Resources
HY	Product A project
IT	Information Technology
JIT	Just-In-Time
KPI	Key Performance Indicator
M	Million
MPS	Master Production Schedule
MRP	Materials Requirements
MTO	Make to Order
MTS	Make to Stock
N/A	Not Applicable
OOS	Out of Stock
POS	Point of Sales
PPPFA	Preferential Procurement Policy Framework Act
QR	Continuous Review
QTY	Quantity
RFID	Radio Frequency Identification
RUL	Remaining Useful Life
SC	Supply Chain

SV	Section Variant
VED	Vital Essential and Desirable
VMI	Vendor-Managed inventory
WIP	Work-in-Progress

CHAPTER 1: INTRODUCTION

Organisations perform zealously to control and minimise inventories, endeavouring to maintain costs and increase profits. Inventory controlling costs and customer service levels are main factors supporting the estimation of an inventory level (He, 2013). Inventory cost subsists the main cost for supply chain management and the organisation. Reducing percentage points of an inventory may result in an increase of a company's profit (He, 2013).

An inventory is crucial for the success and supply chain performance of organisations (Madhusudhana and Prahlada, 2009). Inventory costs affect companies' profits (Apreutesei, Arvate and Suciu, 2010). Costs such as insurance, freight, losses, theft, scraps, attributable to damages in the warehouse and reworks increase inventory costs. A decline of inventory costs increases profit and savings in the supply chain (He, 2013).

Raw materials, work-in-process (WIP) and semi-finished or finished products, define inventory (He, 2013). Goetsch and Davis (2014) recognise three types of inventory: (1) Inventory of raw materials required for production; these are materials filling the warehouse, waiting to be transformed. (2) The second inventory is the WIP inventory of the semi-finished goods; WIP includes all transformed and completed materials, for customer collection. (3) The third inventory is the finished goods inventory; these goods or products indicating finished products.

The WIP and inventory levels should be controlled to determine the optimal or required product demand (Srinivasan and Viswanathan, 2010). Kurata (2014) provided a definition of inventory by linking it to a strategy called inventory pooling, a strategic tool that helps to control WIP and inventory levels. The author further suggested that inventory consolidation at a central location, reduce inventory levels. These facilitating measures or tools contribute to reduction, management and control of inventory levels.

In support Madhani (2012), suggested that successful value chain requires cross functional integration. The benefits associated with cross functional support include:

- Reduced inventory level from encompassing precise information of inventory availability.
- Improved customer service and retention resulting from an improved ability to meet delivery on time.
- Increased responsiveness by working across various sales channels, whilst considering production constraints.

Despite the suggestions from other authors on the strategies to improve inventory management, the authors on the current research did not identify publications which attempt to analyse inventory management and challenges associated with inventory management in the case study company. Hence, this study explores the causes of high inventory levels in the case study company and suggest the strategies to improve inventory management.

1.1 Background and description of the problem

Inventory inaccuracy refers to the discrepancy between the actual inventory and the recorded inventory (Rekik, 2011). Inventory inaccuracy occurs when the inventory information within the enterprise resource planning (ERP) system does not match the physical or available stock. Rottkemper, Fischer, Blecken, and Danne, (2011) studied the challenges associated with the humanitarian operations and identified inventory relocation as a major challenge. The author further found that the high fluctuation in demand and supply creates problems in inventory management. In the instances where the demand is not predictable in advance; it is difficult to keep the stock for locations, requiring instant supply. Supply chain requires proper strategic planning to manage the inventory challenges (Rottkemper *et al*., 2011).

Lopez, Mendoza and Masini, (2013) maintained that inventory challenges occur because of stock shortages and unreliable suppliers. Caulfield (2014) conducted a study on the effectiveness of inventory management in Australia and identified

unreliability of suppliers as the main challenge. There is an agreement among the scholars suggesting that the suppliers play the critical role in inventory management. Zhu, Hong and Lee, (2013) presented the scenarios for reducing inventory shrinkage and concerning inventory inaccuracy.

Kadric, Bajric and Pasic, (2017) suggest lead-time as another challenge associated with inventory management. Lead-time duration causes stock-out, especially if the reorder outlet depends on the lead-time. In this case the organisation risks a deficient stock situation, this may cause the production to come to a standstill. Jiang, Xing, Hou and Zhou, (2015) indicated that the uncertainty of the lead-time, greatly influences the ordering strategy.

The order picking process was identified as a time-consuming process, costly to the warehouse Zhao, Fang, Huang, George and Zhang, (2017). Concerns on the inventory costs, not explicitly associated with inventory levels, result in suboptimal decisions regarding controlling inventory level, leading to excess inventories and additional costs Im, Han, Koo and Jung, (2009). According to Im et al., (2009) several organisations face challenges concerning ordering and demand forecasts, using the push system. The push system cannot manage variability; it increases inventory levels (Im *et al*., 2009)

1.2 Problem statement

The case study company faces the challenge of controlling the competing customer demands, long lead times and voluntary stock demands which affects the company profit. In support Apreutesei *et al.,* (2010) stated that inventory affects companies' profit. Companies endeavour to mitigate the challenges should ensure that inventory is shipped punctually to avoid obsolescence.

Pourakbar, Van der Lann and Dekker, (2014) conducted a study on the end-of-life inventory problem with phaseout returns and identified that managing of service parts

are major challenges for companies because the production of service is discontinued when the part enters its phase of the service life cycle. With the risks of obsolescence, strategic decisions are necessary to keep or remove the product from the market. Procurement decisions must consider the volumes of materials to be ordered to avoid order cross-over. Order crossover occurs when the order arrival sequence differs from the order issue sequence when an order's lead-time exceeds the subsequent order's lead-time (Wensing and Kuhn, 2015). Stochastic lead-times in the enterprise resources planning system, cause orders arriving before the agreed delivery dates, leading to a decrease in inventory. Wensing and Kuhn (2015) provided a distinction between the lead-time and the effective lead-times. Effective lead-times are associated with the deliveries.

Sahin, Kazilashlan and Demirel, (2013) conducted a study on the forecasting of aviation spare parts demand, using Croston based methods and artificial neural networks (ANN). Managing spares inventory can be a complicated and a difficult task because of forecasting difficulties, ANN was developed to manage this type of forecasting. Badar, Sammidi and Gardner, (2008) mention the costs associated with large inventories and large backlogs, will influence profitability of an organisation. A useful ordering strategy in procurement is crucial, ensuring ordering correct quantities of items, delivered punctually.

1.3 Justification

The researcher did not identify any academic examination in the area of the study; hence the high inventory levels study was conducted in the case study company. More literatures discuss the inventory topics, providing various inventory angles. Jalali and Van Nieuwenhuyse, (2015) conducted systematic literature review in academic articles published between 1998 and 2013 to find ways to optimise to inventory challenges. They identified simulation as a most dominating approach as a way of controlling inventory. Various researchers managed to solve complex inventory

challenges, using simulation optimisation. They also identified most challenges are based on supply chain processes and procedures.

Goetsch and Davis (2014) mention that just-in-time attempted to drive inventory to zero. The author further stated the main objectives are to keep the inventory low without shutting down production. There is always going to be inventory in production or manufacturing in a form of raw materials waiting to be processed. WIP, comprising materials and parts placed in various production stages, will continue to exist.

1.4 Assumptions

The study is based on the assumptions below:

- All employees responsively participated in the questionnaires.
- The information employees provided, should be correct and a true reflection of their knowledge.
- Management provided their support by allowing employees time to participate.

1.5 Limitations

This research was conducted in the case study company, concentrating on the factors that cause high inventory levels. Because there was no clear identification of specific areas encountering challenges with inventory levels, most functional areas within the case study company were studied.

The research concentrated in the areas listed below, within the case study company:

- Business development processes used when the opportunities arise and the way the deals are closed, were studied. The study was conducted, based on the concerns raised by employees regarding Business Development (BD) employees

who accept contracts or orders from customers that carry lead-times, not favourable to the company's operations.

- Supply chain or procurement processes, such as quotations and tendering processes were studied.
- Production area where WIP, cost of sales, scrap materials and processes were studied. Production area is a place where physical execution occurs; it is a place where to materials are issued and assembled or processed to manufacture products of case study company.
- Sales performance where programme managers link or associate material delivery dates to the procurement delivery dates.
- Warehouse processes and designs affecting storage and issuing of materials from the warehouse.
- Quality processes as mentioned by employees, are not matured enough to ensure that rejected items are identified and distributed punctually to suppliers for repair or replacement.

1.6 Research questions

Defining research questions is a critical step or guide in research (Pasandideh, Niaki and Nia, 2010). The research questions below, assisted to establish answers to identify the causes of high inventory:

- What are the causes of the high inventory levels in the case study company?
- What are the mitigation plans that can be used to control inventory in the case study company?

1.7 Research objectives

The research objectives are:

- To identify the cause of high inventory level in the case study company
- To suggest the strategy to control inventory levels

1.8 Conclusion

Chapter 1 provides an overview of an inventory and its importance in an organisation. The chapter introduces the definitions of inventory and inventory management. It discusses the various forms of inventory and the types of inventory in different organizations. The description of inventory topic was provided as well as the problem statement. Justification in terms of why the topic of high inventory levels was choses and conducted in the case study company was provided. Assumptions were made that all selected employees would participate in the study and management will provide support. Areas where the study was conducted were highlighted, most of those areas are functional areas within the case study company.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter introduces inventory in various organisations in section 2.1. The definitions of inventory and inventory management will be provided in section 2.2. Section 2.3 will discuss the causes of high inventory levels. Section 2.4 will discuss the strategies required to mitigate the high inventory levels. Section 2.5 will summarise all the discussions in this chapter.

2.2 Definitions of inventory and inventory management

Inventory is defined as a raw material, work-in-process (WIP) and semi-finished or finished products reserved with the purpose of re-sell or manufacturing of goods or services (He, 2013). Inventory contained financial value of the business and also cause money to store, protect and distribute to the warehouses. Hence businesses strive to keep the inventory or stock at the optimum level (Jiang, *et al*., 2013). Faber, de Koster and Smidts, (2013) investigated how inventory management is planned, organised and driven by task complexity and marketing dynamic. A model was developed and tested linking inventory management, task complexity and market dynamics. Inventory management was established to be significantly driven by task complexity and to a lesser extent by market dynamics. Bayraktar and Ludkovski (2010) studied a continuous time model for inventory management with Markov modulated non-stationary demands. The authors identified that the demands have a significant influence on the optimal value and inventory policies. The next section will focus on the causes leading to high inventory

2.3 Causes of high inventory levels

Uncertainty in demand can result in too much stock being ordered and increases inventory. Lopez *et al.,* (2013) mentioned that another way of dealing with inventory

uncertainty is to increase reorder point to provide certain safety stock. Misplaced inventory in the warehouse result in high inventory cost because new materials must be purchased (Zhang *et al*., 2014). Most of the items misplaced cost the company lot of money and time because employees are encountered with a dilemma of having to look for the misplaced items. Operations not efficient constitute and increase operating costs and inventory (Sahin *et al*., 2013). Processes in operations not clearly defined for employees to use do result in sales or operations targets not met. The stock or WIP starts to build up in production or manufacturing areas and it is exposed to damages.

Sagner (2012) provides an explanation of the possible inventory challenges by emphasising the efficiencies on the controls and lack of due diligence processes on document reviews. It was emphasised that accountants do not do physical count, careful review and performance evaluation on the inventory that lead to the misleading information provided. An example was used to indicate that certain companies purchase materials in anticipation of price increases or shortages, this practice led to an increase in the day's materials were held in inventory (Sagner, 2012). It was also revealed that quality of receivables and inventory is difficult to verify even by independent auditors, because accountants are trained to manage financial statements and have less knowledge on the condition of raw materials and WIP.

Wensing and Kuhn (2015) elaborate on the concept of effective lead-time as a methodological basis for analysing periodic replenishment processes that may exhibit order crossover. Order crossover is a phenomenon where order arrival sequence will differ from order issue sequence whenever lead-time exceeds the next order's lead-time. Based on the analysis, lead-times were associated with the purchase order whilst effective lead-time was associated with the deliveries. Most of the businesses had their production moving slowly because of the late deliveries (Goetsch and Davis, 2014).

Producing more than what the customers want increases costs (Apreutesei *et al*., 2010). This statement is true in a sense that most customers are only willing to pay for

what they ordered (Goetsch and Davis, 2014). Apreutesei *et al.,* (2010) went further to emphasise the variations in production that occur or exist and are in most cases inevitable and ever-present. The variations that exist in quality, people, machines, environment, jig and fixtures. Most of these variations results in inventory.

Gang *et al.,* (2012) addressed production-inventory challenge by taking into account multistage and varying demand. Effective and efficient production-inventory strategy was established to be a factor that could reduce inventory costs and production cycles.

Other causes of high inventory levels are reworks and delays, the section below discusses the reworks and delays

2.3.1. Reworks and delays

Rework is defined as a process of correcting defective or non-complaint item during or after inspection (Jiang *et al*., 2013). Delay is defined as deferment of a schedule activity because of a certain issue or occurrence that impedes it commencement (Nicholas and Steyn, 2012). Chiu, Chiang, Chiu and Song, (2016) discussed the simultaneous determination of production and shipment decisions for a multi-product inventory system with a reworks process. The study explained that almost all the items are reworked and fully repaired and sold to the customers. This process involves intense quality assurance so that all the reworked items pass the inspection. It can be costly because most items will have to be inspected since they are not added items.

Huang, Chung, Cheng and Wee, (2017) established that the postponement strategy with reworks significantly increases production and the output for customers. The costs of postponement system are not higher than the non-postponement strategy. Goetsch and Davis (2014) mentioned that defects are an expected part of producing a product and defects are to be prevented using effective control systems. They also mentioned that when an organisation does what is necessary to improve its performance by reducing deficiencies such as scraps, reworks the overall costs can

be reduced. Reworks, scraps and waste are classified as traditional costs whilst excessive inventory is classified as hidden costs (Goetsch and Davis, 2014).

Sun, Wu and Hu, (2013) discussed the remanufacturing of used products, the benefits and the challenges. Remanufacturing of the used products produced by companies is more effective and profitable. A firm does not have to acquire products from suppliers. Challenges associated with used products or reworks are product quality. Quality Departments must be more vigilant when inspecting used products to be remanufactured as they can affect production lines or machines.

The success of remanufacturing system depends on the optimal acquisition and inventory control management (Jiang *et al*., 2013). Remanufacturing system requires a greater planning and control models because of its uncertainties. Issues with remanufacturing systems are that quality of the returned products is uncertain. There is a substantial risk of inventory growing if the system is not managed effectively.

Pourakbar *et al.,* (2014) mentioned that if the rework items can be identified as repairable it may be restored to its originality and re-used again. Innovative technology makes customers to update the configuration of the items to the latest configuration, the old items are returned to the original equipment manufacturers (OEM). The returned items are reworked and sold to other customers who might be using old configuration. Table 1 below summarises the causes of the high inventory identified from the literature. These causes will be used to identify the causes of high inventory in the case study company.

Table 1: Summary of causes of high inventory

No.	Causes	Description	Authors
1	Overproduction	Producing more than customer requirement, increases inventory levels and WIP.	(Apreutesei *et al*., 2010) and (Goetsch and Davis, 2014)

No.	Causes	Description	Authors
2	Variation in production	Variation is dissipating through production flow reduces productivity thereby increasing inventory levels.	(Apreutesei *et al*., 2010), (Gang *et al*., 2012) and (Goetsch and Davis, 2014)
3	Misplaced inventory	Stock difficult to locate in the warehouse or production which increases inventory levels and WIP.	(Zhang *et al*., 2014) and (Goetsch and Davis, 2014)
4	Inefficient operations	Inefficient operations detract from the bottom line profit and product quality. Affect company profit and creates scraps that increases inventory levels.	(Sahin *et al*., 2013), (Zhao *et al*., 2017) and (Sagner, 2012)
5	Inventory inaccuracy	Increases inventory attributable to discrepancies	(Zhu *et al*., 2013) and (Rekik, 2011)
6	Make to stock (Ordering strategy)	Raw materials inventory that increases stock	(Im *et al*., 2009) and (Gunalay, 2011)
7	Reorder Point/Level	Reorder point triggers an action to replenish a particular inventory stock. Affect ordering of materials that create imbalances in the warehouse and production.	(Gurgur, 2013), (Lopez *et al*., 2013), (Caliskan-Demirag *et al*., 2013) and (Yadav, *et al*., 2010)
8	Inventory Costs	Insurance costs of keeping materials or stock such as safety stock	(Apreutesei *et al*., 2010), (He, 2013), (Im *et al*., 2009), (Badar *et al*., 2008) and (Goetsch and Davis, 2014)
9	Work In Process	High work in process in production creates high inventory levels and risk of goods getting damaged	(He, 2013), (Goetsch and Davis, 2014) and (Srinivasan and Viswanathan, 2010)
10	Inconsistent lead-times	Affect delivery of materials and create shortages of materials.	(Jiang *et al*., 2013), (Kadric *et al*., 2017) and (Wensing and Kuhn, 2015)
11	Obsolescence	Obsolete items affect both inventory levels, inventory costs and production.	(Pourakbar *et al*., 2014) and (Goetsch and Davis, 2014)

No.	Causes	Description	Authors
12	Reworks and scraps	Delays production, increases inventory costs, increases inventory and impacts on quality.	(Goetsch and Davis, 2014), (Huang *et al*., 2017), (Jiang *et al*., 2013) and (Pourakbar *et al*., 2014)

2.4 Strategies to mitigate high inventory levels

The strategies that will be discussed in this section will provide some insights in terms of how the high inventory levels can be mitigated. According to Apreutesei *et al.,* (2010), the following benefits are provided by just-in-time (JIT)/Lean: Reduction in WIP, elimination of waste and reduction in high inventory costs. Kanban partakes a critical role in reducing inventory especially in production because supplying process is not authorised to make production until Kanban tells it to do so; there is no WIP stored (Goetsch and Davis, 2014). Lean manufacturing is an important tool used in several organisations to increase or enhance competitive advantage. Lean manufacturing employs continuous improvement processes that eliminate waste and costs (Goetsch and Davis, 2014).

Gurgur (2013) focussed mainly on the optimisation of production/inventory system. The study indicated that the inventory level is mostly determined by procurement control parameters. Based on the studies conducted and the impact of unit inventory costs of products, inventory level is sensitive to procurement policies and service level is sensitive to production policies. Kanban is needed in areas where there are more inventory buffers. Goetsch and Davis (2014) mentioned that Kanban is also required to authorise movement of materials or WIP from one process to another.

Goetsch and Davis (2014) mentioned that several companies facilitated JIT/Lean Kanban reduced inventories concerning excessive production costs and managing the inventory. It is fundamental to apprehend that inventory is created significantly attributable to variations or changes found in manufacturing system (Gang, Li, Yin-

Zhen, Jie-Yan, Tanweer, 2012). Kanban allows organisations to save money by assisting organisations to reduce lead-times (Goetsch and Davis, 2014).

Inventory challenges can pose a challenge and it can also be complicated to solve. Jalali and Van Nieuwenhuyse (2015) used simulation optimisation to solve inventory replenishment challenges. Apreutesei *et al.,* (2010) made a presentation of Kanban system and how Kanban can be used in an organisation as a Tool for managing inventory. Kanban is a sign board or a card and it is used to facilitate the flow, bring about pull system and reduce or limit inventory. Kanban system is incredibly important in an organisation because of its ability to reduce costs and inventory through using pull system.

Sharma and Shah (2016) mentioned that experiments were executed to facilitate, assess and improve Lean in the warehouse. Lean and people issues influencing warehouse performance were identified. A proposed methodology comprising seven steps was used. The study established that Lean processes from suppliers are directly related to picking processes and warehouse performance. Customers and suppliers were also established to be directly related to the performance of the warehouse. This argument is supported by (Dibia and Dhakal, 2014). They studied Lean "leadership People Process Outcome" facilitation model. The model they used has benefits such as: People driven, customer centred, measurable outcome and drive for continuous improvement. The other soft benefits are the creation of learning and friendly environment or atmosphere where continuous improvement thrive.

Yadav, Kumar and Singh, (2010) discussed the importance and the effects of learning within organizations. It is important to note that learning boost confidence and can improve productivity. Research conducted by Yadav *et al.,* (2010) using fuzzy model and solution procedure indicate that profit is sensitive to the learning effects of ordering costs, inventory holding costs and defective items. Profit increases with the increase of the number of shipments that might be as a result of learning effects.

A study conducted by Badar *et al.,* (2008) discussed the bullwip effect in supply chain. The main objective of the study was to establish if using information about inventory levels and components of supply line into ordering strategy is superior to the JIT pull system and using point of sale (POS). The bullwip effect is often described as a supply chain instability that often harms firms and customers through excessive inventory. Five strategies with inventory levels information were compared with JIT pull strategy and the usage of POS. There are cases that indicated reduction of the bullwhip effect and other cases did not indicate reduction.

Gunalay (2011) studied the processes of manufacturing items using either MTS or MTO where two various server scheduling policies were compared. The observations made are that neither of the production scheduling policy is dominating the other with regards to the comparisons of costs, inventory holding plus order delay costs. In order to have various results, MTO and MTS policies have to be considered simultaneously. Most of the army companies or organisations usually keep spares or strategic stock to support the products they sold to the clients. Spare parts especially for the old configuration can be difficult to source and to forecast.

Yang and Tseng (2015) combined a traditional deterioration model and quality prediction model to develop a deteriorating inventory model for chilled food. This new model assisted to calculate the quantities and remaining value of the deteriorating food in the warehouse. A proposed model, using a sandwich, was able to quantify quality and remaining value of the sandwiches kept.

Jiang *et al.,* (2013) presented a method for optimal acquisition and inventory control through a remanufacturing system. Three types of inventories were discussed: One for the returned items, the other inventories were for the serviceable and recoverable items. There are advantages and disadvantages associated with this research. Advantages being the protection of environment through using recycled materials and disadvantages are associated with inspection costs required to peruse each and each item recycled to ensure that the items are still in good conditions.

Gurgur (2013) mentioned that the optimal way of ensuring that there is procurement control parameters when customer arrival rate intensify, is to increase the order size rather than increasing or raising procurement reorder point, total inventory will be kept at minimum. Raising procurement level is a temporal measure but raising reorder point will lead to a permanent increase in inventory.

Kadric *et al.,* (2017) estimated the optimal continuous review inventory policy parame*te*rs that reduce risk of stock-out during lead-time. The author further stated that stochastic demand causes a risk of stock-out, to avoid stock-out the system carries sufficient stock. Lead-time demand and its duration are important factors of the reorder point. To lessen the risk of stock-out, the lead-times demand must be high although it might increase the reorder points and costs. According to Zhang *et al.,* (2014) lead-time reduction can improve forecast accuracy, increase a rate at that a business responds to the market and reduces excess inventory.

Kumar, Muddada, Pandey, Muhanty and Tiwari*,* (2013) developed a three-stage inventory model to address the outsourcing issues with various shipment policies between manufacturer, exporter and assembly point for any manufacturer. A proposed model established optimal combination of the shipping frequencies and shipment sizes. It was also established that inventory holding costs tend to decrease with the increase in the number of exporters.

Studies were conducted that detailed how the inventory challenges can be managed by focussing on the third party or outsourcing (Kumar *et al*., 2013). Although outsourcing of labour or inventory come at a price, but the benefits are significant, benefits such as decent quality, reduced costs of managing inventory and improve operating efficiency.

The figures below, from Lopez *et al.,* (2013) elaborated on the economic order quantity (EOQ) discussions. Companies tend to take a discount offers from suppliers by

purchasing significant volume of materials, whilst this minimises the cost of ordering, it increases the holding costs.

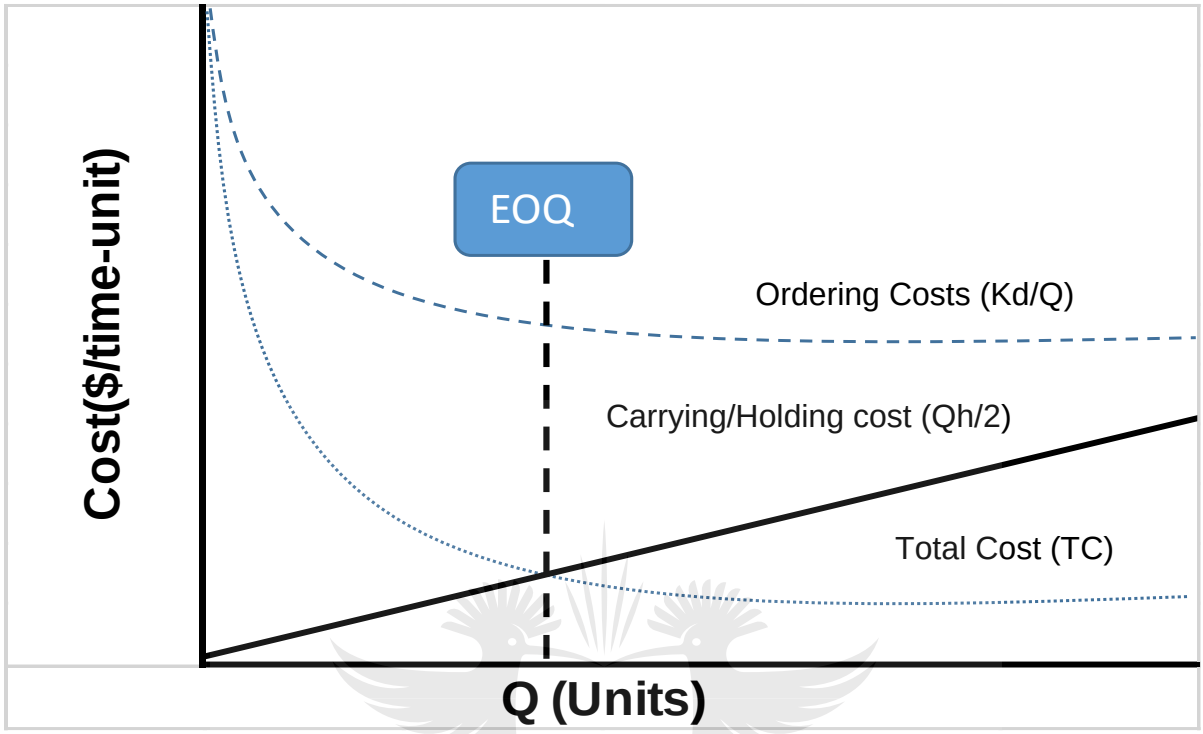

Figure 1: Inventory cost trade-off (Lopez, et al., 2013)

The figure above explains the subject of ordering more quantities attributable to the discount offered by the supplier, but this might increase the inventory holding costs. The total cost per unit is the sum of ordering and holding costs per unit. The ordering cost per unit is calculated as the product between the ordering costs (*K*) and the number of orders placed in time unit (*d/Q*). Holding cost per unit is computed as the product between the average inventory level (*Q/2*) and the holding costs (*h*).

Lopez *et al.,* (2013) presented an application where quantitative demand forecasting methods and classic inventory models are used to achieve inventory reduction and improved customer service levels. Using ABC classification was emphasised, and it is useful in ensuring that the most used and expensive items are ordered punctually and managed correctly to ensure that the inventory is managed. Increasing safety stock

normally assists to manage demand uncertainty and lead-time but it can conversely increase costs if the items purchased are not used on time. EOQ policy was criticised because of its failure to respond to peak demands. Based on the analyses conducted it was established that the continuous review (QR) policy is the best policy because it assists to keep the company's inventory levels low and reduces costs.

Devnani, Gupta and Nigah, (2010) conducted a research on using ABC and vital, essential and desirable (VED) analysis of the pharmacy store of a tertiary care teaching, research and referral healthcare institute of India. As explained in the previous sections, ABC analysis is an important tool that assists to identify and categorise items according to their usage, criticality and costs. Attributable to budget constraints proper inventory controls in pharmacies and hospitals are important to ensure that there's always stock of medicines and conversely enough stock is kept not too much because of shelve life. VED analysis is one of the most important tools, it works similar to ABC analysis and assists to classify the items according to the status, such as: Vital or critical for the survival of patients, essential or lower critical and desirable or low. Combination of the two Tools assist to put stringent controls for optimal use of funds and elimination of out of stock situation.

Pasandideh, Niaki and Nia, (2010) studied the partnership of retailer-supplier through a vendor managed-inventory (VMI) and developed an analytical model to investigate the effect of crucial supply chain parameters on cost savings realised from collaborative initiatives. VMI and Tools such as electronic data interchange (EDI) are important Tools that assist a customer and a supplier to share information about orders. Bourlakis *et al.,* (2011) mention the benefits of EDI such as: improved management of warehouse and gaining competitive advantage through partnership between the supply chain members. A model was created using EOQ policy when the shortage is backlogged through VMI. Results from the model displayed that VMI facilitation on EOQ has the ability to reduce costs supply chain. Rodriguez and Vidal (2009) under VMI developed a heuristic method for the inventory control of products

with a short life cycle. Heuristic allows a better inventory allocation through the supply chain, thereby reducing inventory and risk of obsolescence.

Lopez *et al.,* (2013) mentioned in the classic and effective approach to inventory management that a company in Guadalajara had a challenge when it was using naïve method to forecast demand. Naïve forecast is the easiest forecasting method and it implies that the value of observation at a certain period will represent the forecast for the next period. The company introduced ABC classification method and continuous review (Q,R) that managed to reduce the inventory and keep it at minimum. Q,R policy ensures that an organisation keeps the inventory level at minimum throughout the year.

Gang *et al.,* (2012) mentioned that efficient and effective production-inventory strategy could reduce unnecessary funding and inventory costs from inventory challenges. Caulfield (2014) conducted a research on managing blood inventory. Blood inventory was managed effectively by introducing minimum and maximum inventory level by blood type. Safety stock calculations were used to set up a minimum inventory level. To ensure the blood levels do not exceed the maximum targets, appointments with the filling donor were planned properly and communication channels to handle the appointments were developed.

A research was conducted on the investment of radio frequency identification (RFID) that assists to locate the misplaced inventory and improve the lead-times in supply chain. Although this innovation was applied by suppliers of the retail industries, the analysis indicate that RFID's can be applied in several industries. To have traceability of the stock within the warehouse, it is important to invest in Tools that will assist trace and locate the lost stock, radio frequency identification (RFID) may generate high productivity in the warehouse but at the same time it might not do the same in other warehouse (Karigarannaki *et al*., 2011). Warehouse fully automated does not really need the service of RFID.

Zhu *et al.,* (2013) mentioned that although RFID is expensive but the benefits of using it are enormous because it can locate lost items faster than any machine or human being. Zhu *et al.,* (2013) conducted a research on optimal ordering policy of risk-averse retailer subject to inventory. The research was based on the inventory inaccuracy. Using RFID was emphasised concerning its advantages and disadvantages. The advantages being the easy and quick method of tracing or locating lost stock and disadvantages being the expensiveness of RFID compared to the physical inventory audits. Zhang *et al.,* (2014) discussed the uses of RFID that was hailed as a major innovation to solve challenge resulting in misplaced inventory and the reduction of lead-times using RFID. Using the model assumption, it was established that without the adoption of RFID technology the supply chain can avoid costs, but it will suffer the loss caused by misplaced inventory and the long lead-times to order new materials. But with the adoption of RFID technology lead-times can be reduced and misplaced inventory can be easily located. Bourlakis *et al.,* (2011) mentioned that RFID was successfully utilised in supply chain process because of its ability to manage the flow of goods and information throughout supply chain.

Sahin *et al.,* (2013) mentioned that a Crozen-based method and ANN were compared concerning their correctness in forecasting the spare parts. ANN was proven to provide accurate forecasting for spare parts demand. This study also emphasises important points where businesses want to manage inventory by keeping less parts but conversely business, such as army sector carry spares in the warehouse to support their products in the fields. In order to protect the environment organisations should also recycle or remanufacture their products.

The purpose of inventory control is to best satisfy customers demands (He, 2013). Demand is a crucial factor influencing the inventory control and it is positively proportional to the inventory level. He (2013) applied Improved BP neural network model to predict inventory level of an automotive company. BP Neural has advantages of classification and prediction but conversely it has challenges such as slow convergence and easily converging to minimum forecasting. There should be

cooperation of suppliers, manufacturers and wholesalers to realise the efficiency of the BP neural network. A model was constructed to test the prediction of the BP neural network. BP algorithm did not only exceed the standard algorithm, but it has also outperformed certain other BP algorithm on the indicators as a good Tool for inventory prediction. This method proves that by building a good relationship with suppliers there can better and most effective ways of forecasting deliveries from suppliers and reaching agreements on the deliveries of materials.

Badar *et al.,* (2008) used the bullwhip effect in the supply chain study of various ordering strategy. Bullwhip effect refers to a situation where demand variability increases as one moved upstream in supply chain. The beer game was used as study to assess customers' orders without carrying excessive inventories. The graph for cost and profit against time was plotted using seven cases such as cos and profit. The graph indicates that more information provided for inventory and components along supply line from over 80% cases, the bullwhip effect is reduced.

Srinivasan and Viswanathan (2010) conducted a study on the optimal work-in-process inventory levels for high-variety, low volume manufacturing systems with a goal to minimise WIP inventory. A heuristic method was used to reduce the number of candidate configurations evaluated in the search for optimal solution. The method was established to be useful for the challenges with the setup and processing times. WIP are visible in the manufacturing stages and it is something that cannot be reduced to zero as long there is still manufacturing processes taking place. The management of WIP is important to ensure that it does not increase the inventory.

Thomas and Meller (2013) demonstrated how a set of analytical models can be used to assess warehouse performance using example of a manual, case-picking warehouse. The models depend on the size of the storage area such as aisle length. If the design is good there can be significant savings in labour and overall picking performance in the warehouse. Szymszal, Gajdzik, Piatkowski and Klis, (2012) used a simple spreadsheet that effectively monitored the inventory. This was made possible

by keeping data base in the spreadsheet updated at the end of each day. Formulas were created and calculations of ordering costs, transportation and ordering costs were established to be correct.

Rottkemper *et al.,* (2011) discussed the inventory relocation for the disaster settings in humanitarian operations. The article presents a situation where the humanitarian operations have various regional depots supplied by central depot that in turn is supplied by a global depot. In case of shortages of goods in one depot attributable to increase demand of the humanitarian relief items, the stock can be requested from the other depots and goods can be requested from the neighbouring depots, but the challenge may arise when most depots are affected.

Mayer (2012) discussed the cash to cash cycle for various organisations concerning how cash should be planned and managed to purchase materials that will only be used for production and to control inventory. Kurata (2014) studied how inventory pooling works when product-availability-conscious customers abandon a provided purchase if the items are not in stock. Three choices among the three types of inventory system were considered: decentralised system, centralised system and the echelon inventory system. A mathematical model was used to demonstrate the three types of inventory systems. When several retailers in supply chain is significant enough and most customers are product-availability conscious, decentralised system is the best. Low demand and lead-time tolerant situation, inventory pooling is the best.

Akansel, Emel and Hacioglu, (2011) studied the optimal control of inventory accumulation in selective assembly processes. A proposed loop algorithm provided an effective method in reducing or decreasing surplus component inventory in a selective assembly process. It was mentioned that it may be essential to exchange manufacturing parameters by checking the components in the tolerance spectrum to keep surplus inventory under control.

Outsourcing of various functions such as stores, or warehouse can be useful concerning managing inventory because the responsibility lies with the company managing the inventory. Jiang *et al.,* (2015) conducted a research on an optimisation model for inventory systems and the algorithm for the optimal inventory costs based on the supply-demand balance. Model assumption was made using the central warehouse and the sub-warehouses. Sub-warehouses are supplied by the central warehouse and the central warehouse buys materials from other suppliers. Both warehouses set minimum inventory targets to monitor inventory levels and to ensure that they do not run out of stock.

Remanufacturing of used products is a best way of saving costs although it requires good policies and processes to be developed to manage the return stock (Sun *et al*., 2013). The return policy is depended on the demand and influenced by the acquisition price. An organisation determines its replenishment quantities of materials required.

Ko (2010) developed a framework for a precast fabricator to reduce inventory. The framework of reducing inventory proposed three steps to reduce level of finalised goods inventory indicating: Time buffer evaluation, due date adjustment and production scheduling. Time buffer partakes a vital role in finishing production late that can be ideal for reducing finalised goods inventory. It does this by adopting or using fuzzy logic that is effective in processing unknown information. The adjustment is pulled with the buffer to support the schedule with less inventory. The goal of having time buffer cannot be achieved without having a production schedule that provides direction and sequence of activities. Table 2 below emphasises the mitigation factors of the causes of inventory levels. The mitigations factors in table are important in finding viable solutions to high inventory levels.

Table 2: Mitigation strategies for high inventory

No.	Mitigations	Descriptions/functions	Publications
1	Kanban	Pull signal to produce. Ensures that companies manufacture what is needed and required. Reduces WIP and inventory holding.	(Apreutesei *et al*., 2010) and (Goetsch and Davis, 2014)
2	Radio Frequency Identification	Locates misplaced inventory. Monitors and track stock movement and lost stock.	(Bourlakis *et al*., 2011), (Zhang *et al*., 2014) and (Zhu *et al*., 2013)
3	Economic Order Quantity	Calculates optimal inventory policies. Minimises costs of ordering. Manages inventory costs and reduces shortages of materials.	(Goetsch and Davis, 2014), (Gurgur, 2013) and (Lopez *et al*., 2013)
4	ABC classification	Helps to manage inventory and ordering of parts. Categorises items according to their usage and status. Ensures effect ordering and effective inventory management.	(Beheshti *et al*., 2012), (Devnani *et al*., 2010) and (Lopez *et al*., 2013)
5	Learning Effects	Increases efficiency of inventory and productivity.	(Yadav *et al*., 2010) and (Goetsch and Davis, 2014)
6	Remanufacturing systems	Helps to reduce inventory impact of product in final disposal	(Jiang *et al*., 2013) and (Sun *et al*., 2013)
7	Vendor Managed Inventory Systems and Electronic Data Interchange	Suppliers controls inventory on behalf of a client. Improves coordination between suppliers and customers. Assist in sharing of information between suppliers and customers.	(Rodriguez and Vidal, 2009)
8	Pull system	Minimises inventory holding and reduces WIP. Improves productivity.	(Gurgur, 2013)
9	Lean manufacturing	Reduces waste and inventory costs	(Goetsch and Davis, 2014) and (Sharma and Shah, 2016)
10	Planning	Planning to manage inventory effectively	(Faber *et al*., 2013) and (Sun *et al*., 2013)
11	Partnership	Partnering with suppliers to manage and control deliveries of items in order to keep inventory at minimum.	(Goetsch and Davis, 2014) and (Pasandideh *et al*., 2010)

Bourlakis *et al.,* (2011) mentioned that more significant manufactures exploited information technology (IT) supported material handling systems such as materials requirement planning (MRP) and manufacturing resources planning (MRP II) to manage the flow of materials and inventory in line with the production schedules. Good ERP systems can be beneficial with the automation of various functions such as purchasing, inventory, invoices, delivery status, production schedules and tracing of materials.

2.5 Conclusion

Chapter 2 introduced inventory and inventory management and the definitions. Causes of high inventory levels were discussed. Causes such as misplaced inventory in the warehouse, work in process, variation in production, inconsistent lead-times from suppliers were discussed. Inaccurate stock in the warehouse has been discussed as the cause of high inventory level. Inefficient operations often lead to reworks and scraps which increase the inventory levels and inventory costs.

Strategies and tools that help to reduce and control inventory were discussed. Tools such as Lean, JIT, Kanban were proven to be very useful in reducing and controlling inventory by various authors. Tools such as RFID play critical role in locating misplaced inventory. VMI and EDI tools have been discussed as tools that provide a link between the suppliers and customers in order to improvement communication channels and deliveries. ABC and VED were discussed as strategies that help to reduce costs and inventory by ensuring that the items are ordered on as and when they are required

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter introduces the research strategies, research methods and research approach used to collect data and to answer the research questions. The current study depends on the multiple data collection methods to increase the chances of obtaining the necessary information and to answer the research question (Sanders and Wagner, 2011). Qualitative is defined as a research m*et*hod that does not use numeral information but instead, uses words and pictures to describe the phenomenal (Runeson, Host, Rainer and Regnell, 2012). Runeson *et al.,* (2012) defined quantitative research as the opposite of a qualitative method. It uses numeral data and statistics to describe the phenomenon. This chapter enlightens how data will be summarised from the raw data, into meaningful information.

3.2 Research questions

- What are the causes of high inventory levels in the case study company?
- What are the mitigation plans and controls that can assist in reducing an inventory?

3.3 Research strategy

Research strategy is the systematic investigation into and study of sources in order to establish facts and reach new conclusions (Chouikha, 2016). According to Runeson *et al*., (2012), each study has its own strategy, serving various purposes. A single case study is deployed in this study. Runeson et al further explained types of research strategies, namely: case study, survey, experiment and action research. Survey is the collection of information from specific people or sample of population. Experiment is characterised by measuring the effect of manipulating one variable on another variable. Action research changes the aspects of whatever is focused and is closely related to case study. This study deployed case study as a research strategy.

3.3.1 Case study

The literature defines a case study as a study of a phenomenon in its own setting (Chouikha, 2016). The current study endeavours to study the concept of inventory management and its associated challenges within the South African defence force environment. The findings on the current study cannot be generalised in various environments, therefore the case study was selected as a preferred method to answer the research questions. According to Chouikha (2016), a case study strategy endeavours to answer questions, such as “how?”, “why?” and “what?”, using multiple data collection m*et*hods such as questionnaires and document review. According to Kumar (2011), a case study is based on the assumption that the area of study is unique. It should focus on the bounded subject or item.

3.3.2 Definitions of case study as per Runeson *et al*., (2012)

- In software engineering, case study is defined as an empirical investigation or analysis derived from multiple sources of evidence, investigating a small number of instances of software engineering within its real-life context.

- Runeson *et al.,* (2012) provide several explanations and definitions concerning a case study in the following:
  - A case study does not require strict boundary b*et*ween the object of study, and its environment.
  - A case study provides a deeper understanding of the singularities under study.
  - Case studies were criticised for being impossible to generalise and being biased.
  - A combination of qualitative and quantitative study provides an improved understanding of a case study.
  - Case studies is adjusted during the course of the research, that is why it is called a flexible study.

3.4 Research approach

The research approach is the step by step process employed to answer the research question, deriving the theory (Runeson *et al*., 2012). According to Runeson *et al.,* (2012), research approach can be deductive, inductive or a combined method.

3.4.1 Inductive study

Inductive study is normally used in a situation with limited literature in the subject of interest of phenomenon (Runeson *et al*., 2012). The research did not deploy an inductive study because interviews were not conducted.

3.4.2 Deductive study

Deductive approach involves using existing knowledge to assess the environment or test the hypothesis (Runeson *et al*., 2012). The existing literature on the subject of inventory management in general is crucial in developing the questionnaires as a research tool of collecting information and understanding the factors affecting inventory management within the study area. Questions were formulated and distributed amongst employees to provide feedback on inventory level issues. Employees with no computer access, were visited and questionnaires were hand delivered.

3.5 Research methods

Research methods are the tools by which the information is gathered (Gibbert, et al., 2008). Research methods help to collect data or information needed to understand the study. The section below discusses the two research methods used in this study, indicating quantitative analysis and qualitative analysis.

3.5.1 Quantitative analysis

Quantitative analysis was used to collect and analyse a small and significant quantity of data from the company reports and ERP system reports. Runeson *et., al.* (2012) mentioned that quantitative analyses comprise of numbers. One of the quantitative analysis deployed is the descriptive statistic as it uses histograms to represent data. Histograms were used in this study to analyse the inventory information from the ERP system reports. Histograms are utilised in areas with a frequency of occurrence (Goetsch and Davis, 2014). Quantitative analysis is a process of reducing the numbers into a manageable form (Elatia, Ipperciel and Zaiane *et al*., 2016). The information from the company reports was analysed and compared to check the trends

3.5.2 Qualitative analysis

Qualitative analysis was employed to analyse the information or data collected from questionnaires and to analyse the concepts emerging more often. Qualitative analysis was observed as a limited method, to an extent that it forecloses a range of potential answers (Brand, 2008).

Qualitative data involves words, pictures, descriptions and explanations, amongst others (Runeson *et al*., 2012). Qualitative research was criticised for being subjective because the research is physically or psychologically close to the phenomenon observed (Chouikha, 2016).

3.6 Data collection

3.6.1. Introduction

For study that will use large amount of data to be collected, the data will need to be refined. It is very important to carefully select the data sources, organize the data and refine it in a structure way so that it will become easy to find appropriate data during

analysis. In this section various data collection methods were discussed, namely: documents review and questionnaires.

3.6.1 Questionnaires

According to Runeson *et al.,* (2012), questionnaire is defined as the collection of information from a selected number of people or a population. Wagner and Kemmerling (2010) mentioned that it is important to ensure that the questions reach the correct individuals, intending to provide feedback, otherwise there might be no response to the distributed questionnaires. Questionnaires concerning the causes of the inventory were distributed to employees. Employees were provided two weeks to respond to the questions. They were assured anonymity and that the information would not be used to punish any individual or to be presented to the management.

3.6.2 Documents review

Using various and several data sources is advantageous to the study to limit the effects of one interpr*et*ation of a singular source (Runeson *et al*., 2012). If the research only uses documents obtained from the m*eet*ings and does not talk to the people who were present in the meetings, the research cannot claim the compl*et*eness of the study. By having an independent person confirming the content of the documents it will assist validate the case. Company reports and annually statistics, involving inventory, were collected, studied and analysed.

3.7 Unit of Analysis

Units of analysis are the items of study within a research (Cole, 2018). The study used the company reports such as: sales plan, purchase plan, inventory reports and change requests, as the unit of analysis. The study accomplished its objectives and feedback to the problem statement through alignment of adopted research approaches.

3.8 Population sample

Population is defined as the individuals or units of interest, typically there is not available data for all individuals in a population (Halon and Larget, 2011). Sample is defined as a subject of the individuals in a population, there's typically data available for individualsa in a sample. Samples contain less information than a full population, so estimates from samples about population quantities involve some uncertainity (Halon and Larget, 2011).

The study population consisted of document reviews that are five (5) years old starting from year 2014 to 2018. The documents were obtained from ERP system the departments within the case study company, namely: supply chain, warehouse, finance, business planning and production. Reasons for selecting five (5) years period was to ensure that sufficient information is obatined. The study collected opinions from departments and employees directly invovled with the subject matter.

The following criteria was used to obtain the documents:

- The documents must be older than five (5) years counting from year 2018 going back.
- The documents must have been used consistently for more than five (5) years
- The documents must be coming from the ERP system, or the content of the contents of the documents must be coming from ERP system

The criteria used for selecting participants:

- Employees must be working for the case study company for more than five (5) years
- Employees who are experienced and working directly involved with purchasing, inventory and stock, production, sales and project management
- Employees with supply chain qualification, inventory and stock qualifications, production qualifications and sales qualifications

A case study company employs about 500 permanent employees. A total number of about hundred employees that work in the departments mentioned in the previous sections were approached. Only twenty employees participated in the study. The rest

of the employees who were approached but did not take part in the study mentioned the following reasons for failing to participant:

- Victimization by top management
- Trust that the study will benefit them
- Lost confidence in the company
- Lack of interest in the company's improvement processes

3.9 Data storage

The aforementioned sections describe that case studies collect significant information or data. Data or information needs to be stored or kept in a safe place every to be established or retrieved whenever needed for the study. Runeson *et al.,* (2012) mentioned that case studies collect significant, complex and a diverse body of information. It should be ensured that this information is stored in such way that it can be established or retrieved with ease.

The information or data for this research was saved on the company's hard drive and external hard drive with easy names to ensure that it is safe and can be retrieved speedily should a system experience technical challenges.

3.10 Pattern matching

Pattern matching was conducted to establish a link between literature review, operational data and questionnaires. It is logical to find similarities and differences across the cases when using more than one case in a study (Naslund, Kale and Paulraj, 2010).

Table 3 Pattern matching

No.	Literature review	Document review	Questionnaires
1	Overproduction (Apreutesei *et al*., 2010) and (Goetsch and Davis, 2014).	Inventory levels and WIP are high from the reports.	Rate the production or operations processes?
2	Misplaced inventory (Zhang *et al*., 2014) and (Goetsch and Davis, 2014).	Stock shortages due to missing materials.	Are the tools to manage misplaced stock?
3	Inefficient operations (Sahin *et al*., 2013), (Zhao *et al*., 2017) and (Sagner, 2012).	Incomplete designs create changes requests. Stock turnover has been declining from 2016 to 2018.	Rate the operations processes?
4	Inventory inaccuracy (Zhu *et al*., 2013) and (Rekik, 2011).	The stock in the warehouse does not reconcile.	Are there discrepancies between the ERP system and physical counts?
5	Reorder Point/Level (Ordering strategy). (Gurgur, 2013), (Lopez *et al*., 2013), (Caliskan-Demirag *et al*., 2013) and (Yadav *et al*., 2010).	The purchase plan is not in accordance with the sales plan and does not meet production demand?	Please rate ordering strategy?
6	Obsolescence (Pourakbar *et al*., 2014) and (Goetsch and Davis, 2014).	Change requests report show the number of items being modified increasing. Other reasons of the changes are obsolescence.	Is there adequate provision for obsolescence?
7	Reworks and scraps (Goetsch and Davis, 2014), (Huang *et al*., 2017), (Jiang *et al*., 2013) and (Pourakbar *et al*., 2014).	Change requests report show an increase in the number of items that are being modified. Some, if not most, of the items are being reworked and scrapped.	Is there adequate provision for scraps and reworks?

3.11 Improved validity

The validity of the case study should be considered in the beginning (Runeson *et al*., 2012). Triangular validation was conducted to assess or measure if the information

selected is relevant, assisting in providing effective solutions to the identified challenges.

According to Runeson *et al.,* (2012), triangulation means dealing with multiple sources of information or perspectives in a study to provide a better representation of the study conducted. In triangulation, approaching the research with various methods from a variety of angles, can be useful for validity purposes (Naslund *et al*., 2010).The researcher will compare the literature, company reports and questionnaires data sources to validate the research findings.

There are four types of triangulations:

- Data triangulation: Using more than one data source.
- Observer triangulation: Using more than one person or an observer in a study.
- M*et*hodological triangulation: Using more than one method in a study.
- Theory triangulation: Using view points in a study.

The study relied more on data triangulation. Numerous ways or criteria can assess the validation of the research (Gibbert, Ruirok and Wicki, 2008). These criteria depend on the author's perspective or the direction of the research. These criteria are: External validity, internal validity and construct validity. External validity deals with generalisation. In internal validity a research produces a reasonable argument and logical thinking to defend the conclusion or the content of the research. In construct validity a research deals with the conceptualisation of the research during data collection.

Prolonged involvement

Should the study be conducted for an extended period, a trust b*et*ween the research and the organisation would develop, becoming easy to access trustworthy information (Runeson *et al*., 2012). Over the years the investigator collaborated with warehouse

and supply chain employees on various improvement projects. Cooperating on these projects assisted building a healthy relationship and trust b*et*ween supply chain and warehouse employees.

Member checking

Member checking – is it important to obtain information about the subject matter by the participant, checking if the information provided is accurate (Runeson *et al*., 2012). The research report was distributed amongst most participants to check the accuracy of the extracted information.

3.12 Quality assurance of the data

The information was collected through various m*et*hods and from various individuals. As mentioned in the case study section, the collected information was significant. For these reasons, it is crucial to ensure that the study develops into a professional and well accepted document. Runeson *et al.,* (2012) mentioned that research should monitor and evaluate various aspects of the case study to ensure that the findings are relevant.

3.13 Data analysis methods

A researcher should be able to anticipate the type of techniques to be used to analyse data, although it might be difficult in the beginning of the research (Runeson *et al*., 2012). Data was analysed using qualitative and quantitative analyses.

Descriptive statistics were used to analyse the collected information. Descriptive statistics were used to describe the basic features of data in a study, forming the basis of any quantitative data analysis when combined with a graphic analysis. Runeson *et al.,* (2012) mentioned that descriptive statistics, such as histograms, lines charts and pie charts, are used to obtain an understanding of the collected information and

summarise it. A cause and effect diagram was deployed to identify and isolate the challenge (Goetsch and Davis, 2014). A cause and effect diagram is the only tool that is not based on statistics.

3.14 Coding

A well-defined coding schedule is important to conduct a content analysis (Wagner and Kemmerling, 2010). Coding was used to categorise or group the raw data. Reducing data collected through questionnaires was conducted by analysing the collected information. The information was perused, analysed and summarised into themes.

3.15 Challenges

The challenges encountered during data collection were that employees at Case Study Company endeavoured several times to research on inventory levels, but the studies were never comple*et*ed. Obtaining information from employees was difficult. Employees were not keen to provide the information because they did not believe the information would serve any purpose. Analysing complex company reports and minutes to apprehend the meaning of information and to produce a conclusion, was a challenging task.

3.16 Ethics

Certain respondents were reluctant to participate in the questionnaires, concerning that they might be targ*et*ed if they provide information to the research. To alleviate this fear, the research obtained a written communication from the CEO, indicating and explaining a desire to conduct research and it might also be used in the company to improve certain areas within the company. It was also ensured that the answers to the questionnaires provided by the participating employees, would stay anonymous to protect the identity of the participants.

Runeson *et al.,* (2012) mentioned that it is important for a researcher to consider the *et*hical issues in the design, and when reporting on the research. Before they can support or fund the research in global countries, a research *et*hic committee formed to ensure compliance and governance with relevant *et*hical standards and guidelines where a research will have to be v*et*ted. The case study was conducted, ensuring that the identity of the client or an organisation should not be made visible unless the consent is provided (Scholl, 2017). This study was submitted to the military EXCO for v*et*ting purposes and to ensure that the information in the report is correct and true.

3.17 Conclusion

Chapter 3 introduced case study which was used as a research strategy in this study. One case study was used as a preferred because the findings on the study cannot be generalised in various environment. Deductive study was used as a research approach because the study involves questionnaires and document review not interviews. Bothe qualitative and quantitative approaches were used in to gather information. Qualitative approach was used in order to analyse the information gathered from the questionnaires while quantitative approach was deployed to analyse the numbers and figures received from the company reports. Triangulation and pattern matching were performed in order to look for similarities between the literature, document review and questionnaires.

CHAPTER 4: DATA ANALYSIS

4.1. Introduction

The study addresses the critical issue in the case study company, indicating high inventory levels. The evidence to answer the research questions needs quantitative and qualitative analyses. Data collected from the company reports and questionnaires were analysed. The main sections of this chapter are sales plans, purchase plans and inventory analyses. These sections are the main forces of the company's performance. The main objective of this study was to investigate the causes of high inventory levels at case study company and to emphasise the possible causes to find an optimum solution.

4.2. Operational data

The operational data comprises various types of reports, requested from case study company top management. The operational data presents the company's performance over a period. Case study company management was requested to provide 2013 to the 2018 reports. The reason for requesting the information from 2013 is that before 2013, most reports were conducted manually and employees responsible for creating those reports are not employed by case study company anymore. The reports are presented in a form of histograms, pie charts and tables to ensure the ease of reading.

4.2.1 Sales reports

The five-year sales variant report was extracted from the company's records. The reports were obtained from a reliable source within the company. The company applies a fiscal year model, instead of a calendar year. Final consolidated information of the company's performance is released in March (End of the fiscal year), therefore March appears in the graph.

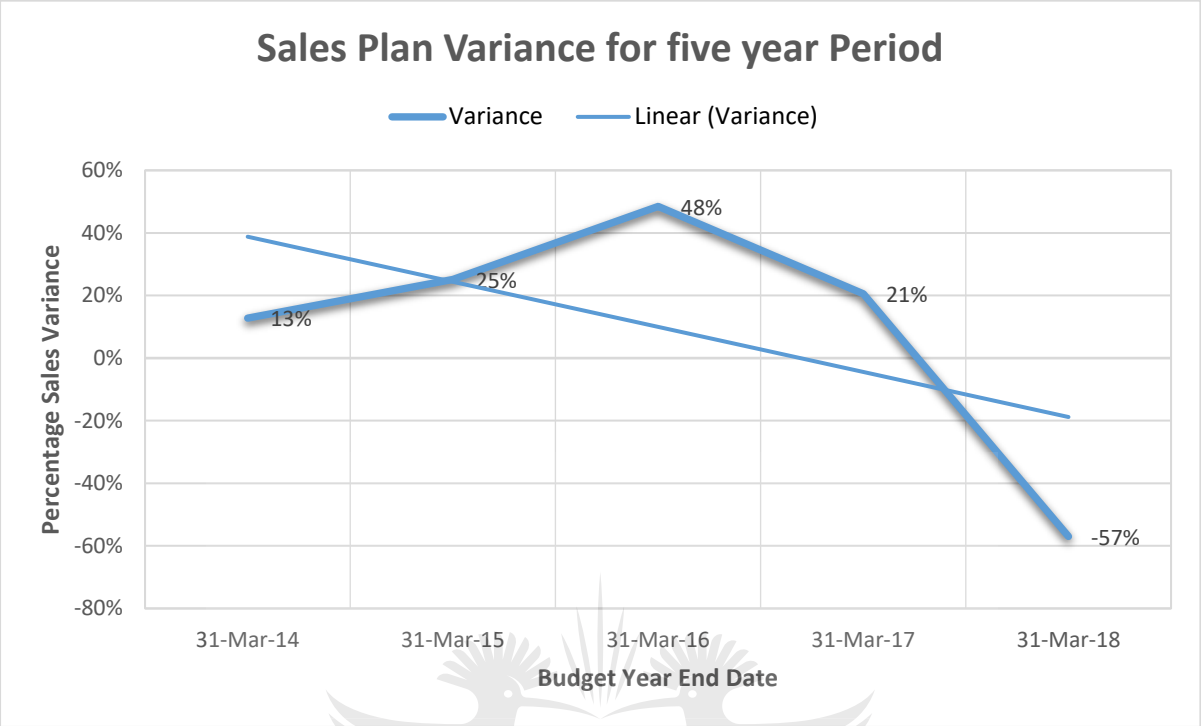

Figure 2: Sales report

The figure above indicates the sales performance for a five-year-period, starting from the fiscal year 2013/2014 to 2017/2018. Between 2014 and 2016, sales performance increased from 13% to 48%. In the fourth year, sales performance declined from 48% to 21%. During the last fiscal year (2017/2018), the performance was dismal because it went down to negative (-57%). Warning signals appeared in year 2016/2017 when performance declined at a faster rate, compared to the growth of 25% in 2014/2015.

4.2.2 Purchasing plan report

Purchase plan indicates materials planned to be purchased for a specific period after finalising the sales plan and activating the Bill of Materials (BOM) on the ERP system. A purchase plan is extracted from the ERP system, varying regularly when the new BOMs are activated, when sales plan changes and with stock adjustments. In

summary, a purchase plan is the end result of the activated sales plan. A five-year purchase plan links to the sales plan, selected in the previous section.

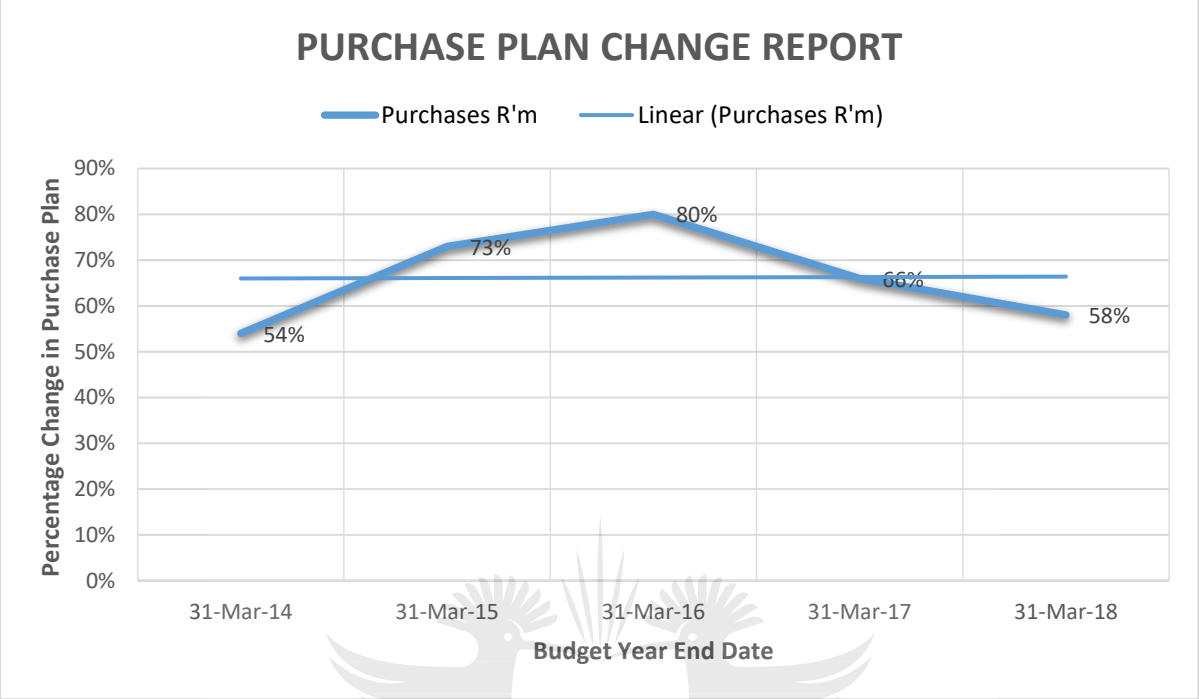

Figure 3: Purchase plan

Figure 3 indicates the increase in purchasing materials annually. In 2013/2014 purchasing materials was 54% and increased by almost 20% during the following year. During 2015/2016, abundant materials were purchased. Material purchasing reached its peak at 80%. During 2016/2017, it was established that purchasing material decreased to 66%; in 2017/2018 it further decreased to 58%.

A comparison was conducted between a sales plan and a purchase plan. A conclusion was reached, identifying a link between the two plans. In 2016/2015, a sales plan reached a peak of 48%; in 2017/2018 it decreased to -57%. The purchase plan reached a peak of 80% during the same year and declined to 58% in the preceding year.

4.2.1.1 Purchase and production plan

Appendix E indicates two production and components delivery schedules. Product A is a major product in the case study company, comprising 70% of sales. The schedules were issued in November 2017 to track high inventory levels. The two tables in Appendix E, indicate the quantities of the systems that must be built and the orders that must be placed with suppliers. Quantities emphasised in red (59) are the systems planned to be built.

After the programmes department supplied the schedules to the supply chain, 59 sales systems orders were placed. Delivery dates for the systems were scheduled for January 2018 until February 2018. Materials were delivered from January 2018 but the numbers of systems that were planned to be executed, were reduced to six systems from the initial planned 59 systems. In summary, materials for 59 systems were delivered but the plan was modified to indicate six systems. Fifty-three systems are still stored in the warehouse.

4.2.1.2 Examples of incorrectly ordered parts

The table below indicates how Cooling unit parts were ordered and delivered to the warehouse. The information was extracted from Qmuzik (ERP system) in November 2017. Part number 004105 is used in Case study company. Part number identify the parts or materials from suppliers and compe*t*itors.

Table 4: Orders for cooling unit

History for part 004105 Cooling unit already delivered				
Line	**Del Date (into warehouse)**	**Qty**	**MRP suggested date**	**First date suggested**
1	20-Feb-17	15	17-Feb-17	
2	03-Mar-17	15	28-Mar-17	
3	22-Jun-17	10	26-Sep-17	23-Sep-16
4	01-Sep-17	15	26-Mar-18	30-Jun-17
5	09-Nov-17	10	20-Apr-18	01-Aug-16
6	09-Nov-17	10	24-Aug-18	01-Aug-16

The table above comprises five columns, explained as follows: (1) The first column comprises of purchase order line numbers; (2) The second column comprise purchase order delivery dates; (3) The third column comprises the quantities; (4) The fourth column comprises ERP/MRP delivery dates; and (5) The last column comprises original delivery date.

Delivery dates emphasised in green, indicate that the cooling unit arrived three days after the original delivery dates. Dates emphasised in red means that the cooling unit arrived three months earlier, or three months before the agreed delivery dates.

Table five above, combined with the aforementioned analysis, indicates that the cooling unit was purchased too early; it could have remained in the warehouse for a longer period before it was issued to production line.

Table 5: Future orders for cooling unit

Future deliveries of part 004105 of the cooling unit					
Line	Purchase delivery date	Qty	MRP suggested date	Days early	Months early
7	2018/02/23	10	2018/10/12	231	7.7
8	2018/04/27	10	2019/04/10	348	11.6
9	2018/06/29	10	2019/04/10	285	9.5
10	2018/08/31	10	2019/05/24	266	8.87
11	2018/10/26	15	2019/06/14	231	7.7
12	2019/02/22	10	2019/08/08	167	5.57
13	2019/06/28	10	2019/08/23	56	1.87
14	2019/09/27	10	2019/10/11	14	0.47
15	2019/11/29	15	2019/11/08	-21	-0.7
16	2020/02/28	10	2020/04/08	40	1.33
17	2020/06/26	10	2020/06/04	-22	-0.73
18	2020/10/30	15	2020/08/06	-85	-2.83
19	2021/04/30	11	2021/06/10	41	1.37

The table comprises six columns, explained as follows: (1) The first column comprises the line numbers for the purchase orders; (2) The second column comprises purchase order delivery dates; (3) The third column comprises quantities; The fourth column comprises MRP/ERP delivery dates; (5) The fifth column comprises the number of early delivery days; and (6) The last column converts days in Column 6 into month.

The first eight rows indicate that the delivery dates of the cooler unit were over six months early. In certain instances, the delivery of the cooler unit were 11 months early, almost a year early, prior execution.

4.2.1.3 Common platform purchase and production plan

Appendix F (Common Platform Purchase and Production Plan) indicates the planned sales and deliveries of the items belonging to the common platforms. Platforms are assembled at Vehicle Systems (VS) branch. It is a branch of the case study company. Materials are delivered at case study company and then relocated to Vehicle Systems. Analysis were conducted from October 2017 to July 2018. VS requires three months to assemble four common platforms.

The appendix indicates numbers of stock for four common platforms in December 2017 and January 2018. The quantities of the common platforms increased to seven in February 2018; this is one month before the fiscal year-end. In March 2018, the quantity of producing common platforms increased to eight, before a sale of four common platform could materialise. Sales of common platform materialised in April 2018 after the 2017/2018 fiscal year end.

4.2.3. Inventory report

The inventory report indicates the stock in the warehouse for a certain period. Analysis were conducted for a five-year period, measuring the stock performance. Calculations

of the percentages of the inventory are based on the planned stock against the actual stock annually.

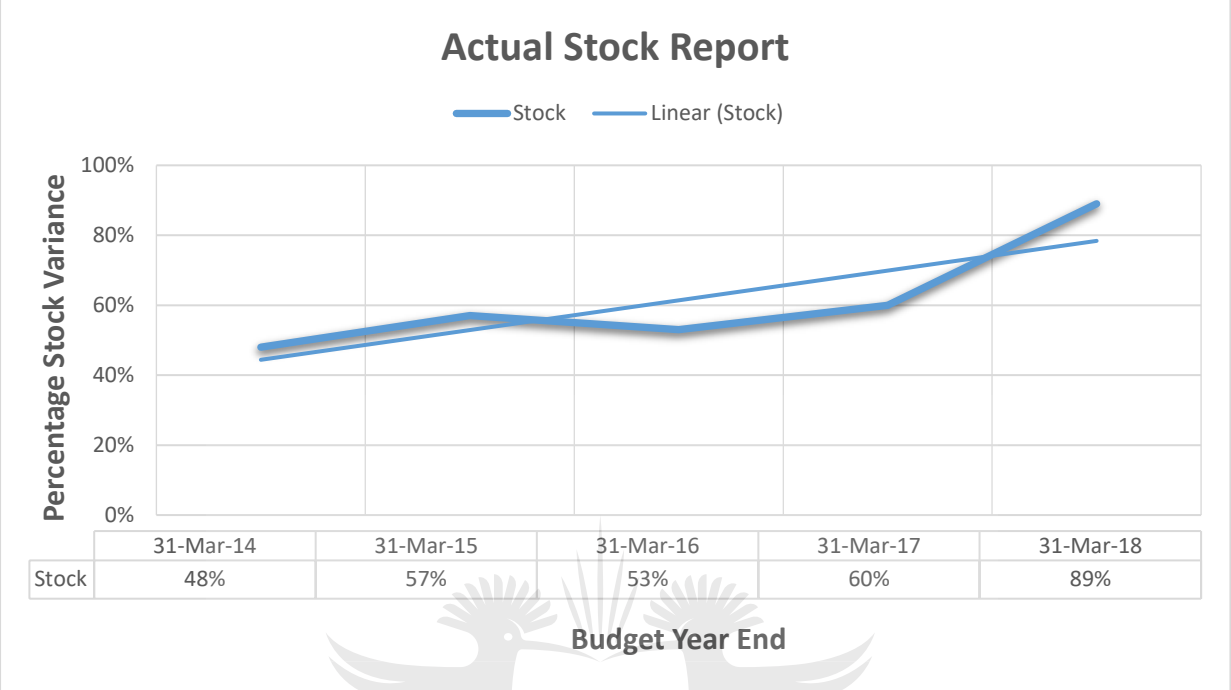

Figure 4: Stock report

Figure 4 indicates that in 2013/2014, the actual inventory was low compared to subsequent years. During the succeeding years it increased to 57%, thereafter it decreased to 4% during the 2015/2016 fiscal year. In the year 2016/2017, the inventory increased to 60% and in 2017/2018, the inventory increased drastically to 89% compared to alternative years. The tendency indicates that for a period of five years the inventory in case study company increased.

Stock turnover

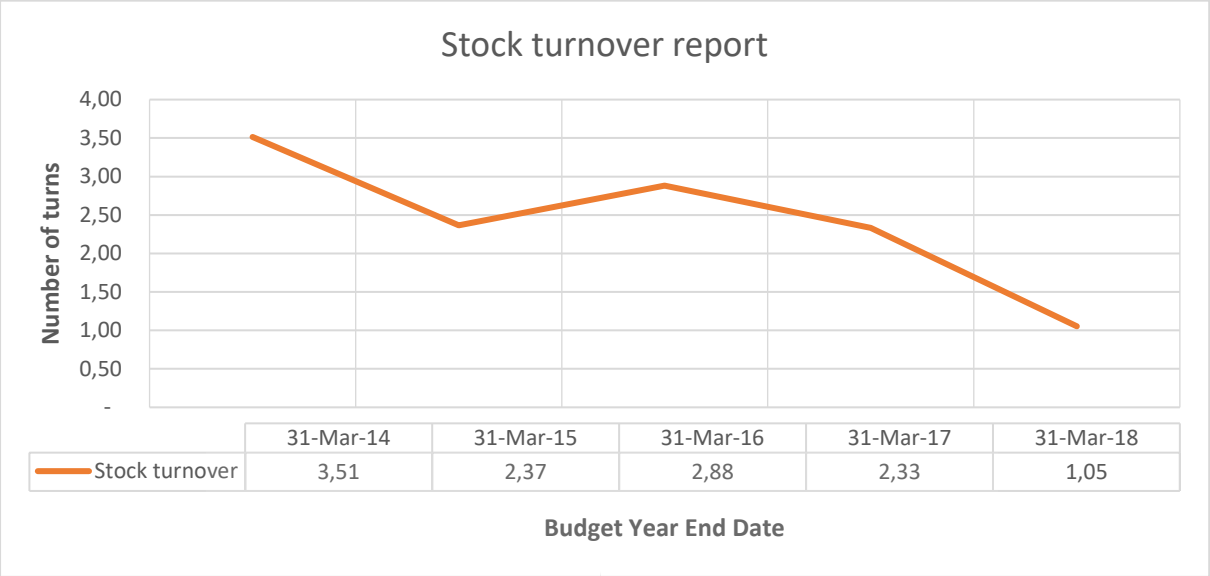

Figure 5: Stock turnover report

Figure 5 indicates a stock turnover, measured for a period of five years. The following formula was used (Madhusudhana and Prahlada, 2009):

$$Stock\ turnover = \frac{Cost\ of\ Sales\ of\ goods\ sold\ for\ a\ period\ of\ 12\ month}{The\ actual\ inventory\ for\ a\ period\ of\ 12\ month}$$

In March 2014 the stock turnover was high compared to alternative years. Between 2015 and 2017 the stock turnover was inconsistent. It came down from 3.51 in 2014 to 2.37 in 2015; it elevated to 2.8 in 2016. In 2017, stock turn decreased to 2.33 and in 2018 stock turnover reached a lowest level of 1.05, compared to other years.

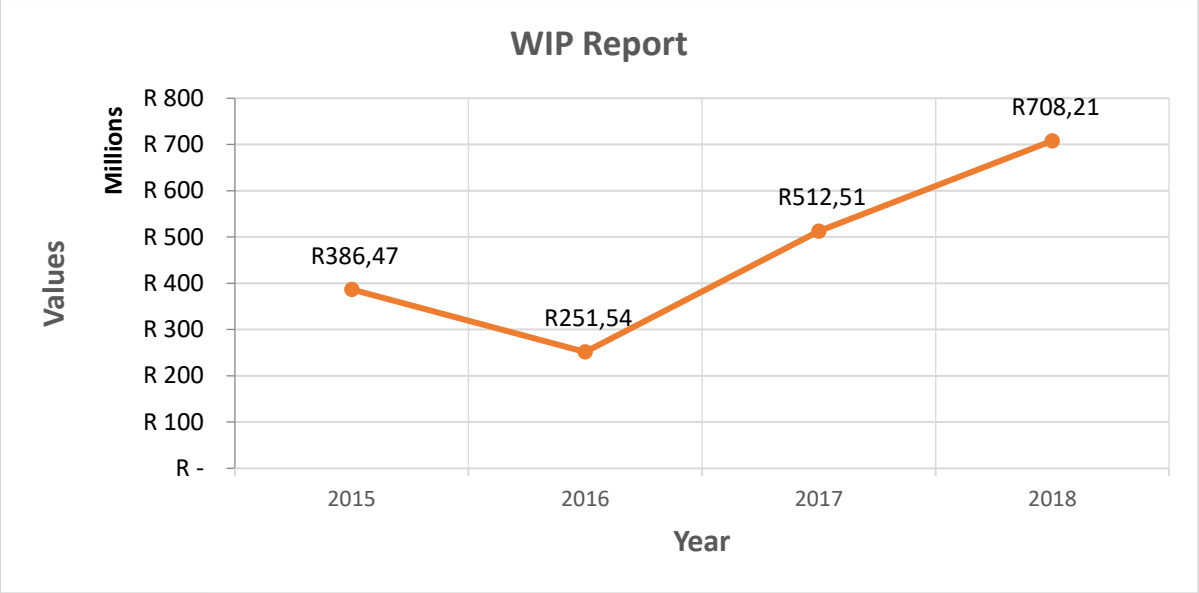

Figure 6: Work in process report

Figure 6 above indicates the WIP report for a period of four years. Information for the fiscal year 2013/2014, could not be established from Finance department.

The WIP was high in 2015, compared to 2016. In 2016, the WIP was low compared to alternative years. The WIP increased from the fiscal year 2016/2017, reaching the highest during the fiscal year 2017/2018 compared to alternative years.

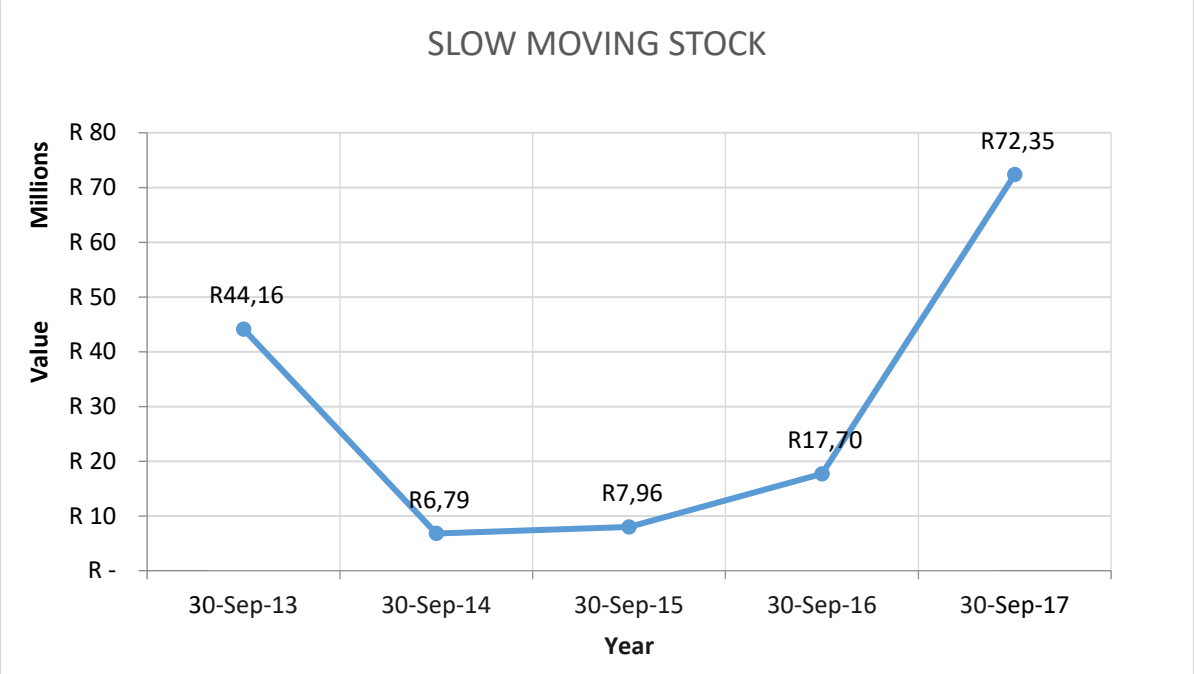

Figure 7: Slow moving stock report

The figure above indicates stock ageing or slow-moving stock for a five-year period. The information was extracted in September 2018; The Finance Department exploited September as a measure for all the years. The figure indicates that slow moving stock was high compared to the year 2014 and 2015. In years 2015 and 2016, slow moving stock was constant. In the year 2017 slow moving stock increased rapidly. In the year 2018 the slow-moving stock reached an elevated level. During 2018, the slow-moving stock increased.

4.2.4 Change requests (CR) report

Case study company follow a change request process to change the design of an item. The information was collected from the system engineers. They indicated that they record the CRs manually when the CRs are approved. Systems Engineers also mentioned that the CR report was created for one of the most significant projects in case study company. Section Variant was chosen because of its size, compared to the other four variants.

Appendix D indicates the quantity of CRs measured. On 22 July 2016, the total of CRs were 114; 29 CRs were closed and 85 were opened. August to September 2016, established several opened CRs decreasing; in October CRs increased to 68. In November 2016 CRs declined until May 2017. The numbers increased to 62. B*et*ween June 2017 and the second week in September 2017, CRs were low compared to all the other months. In certain instances, a price of a single CR can be expensive compared to 10 CRs. It can also be expensive concerning the schedule impact on the project.

4.3. Questionnaire

This section discusses information obtained through the questionnaires from employees at case study company. The questions that were asked to the participants were based on the causes of the themes high inventory levels as discussed in chapter 2. The questions interrogated the causes of high inventory levels in the case study company. Participants answered and rated the questions using five (5) levels likert-type scale.

4.3.1 Analysis of forecast model

- Question 1: Is there a forecast model?

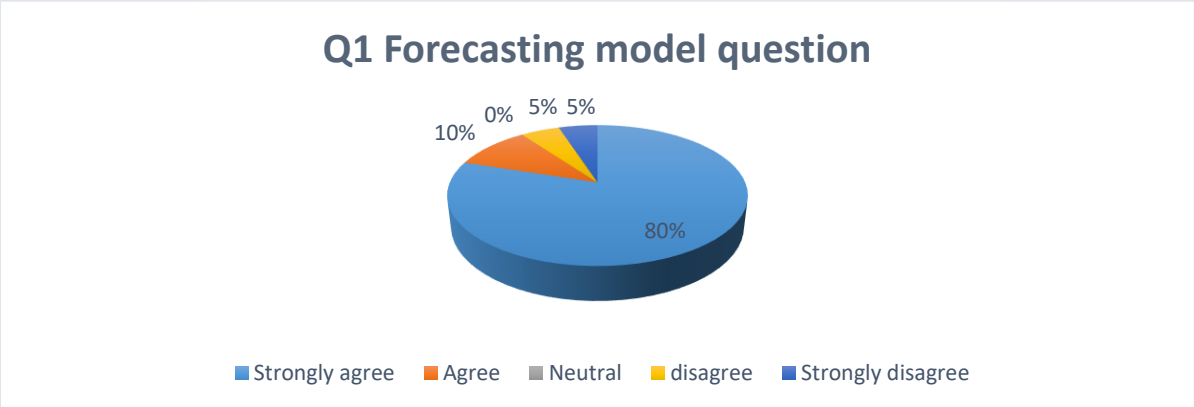

Figure 8: Forecasting model

Figures 9 directs a question about the forecasting of sales and inventory in case study company. The figure indicates that 90% employees at case study company strongly agree that there is a forecasting model, whilst 10% of the employees do not believe the forecasting model exists.

- Question 2: Are there 'best ways' in managing an inventory?

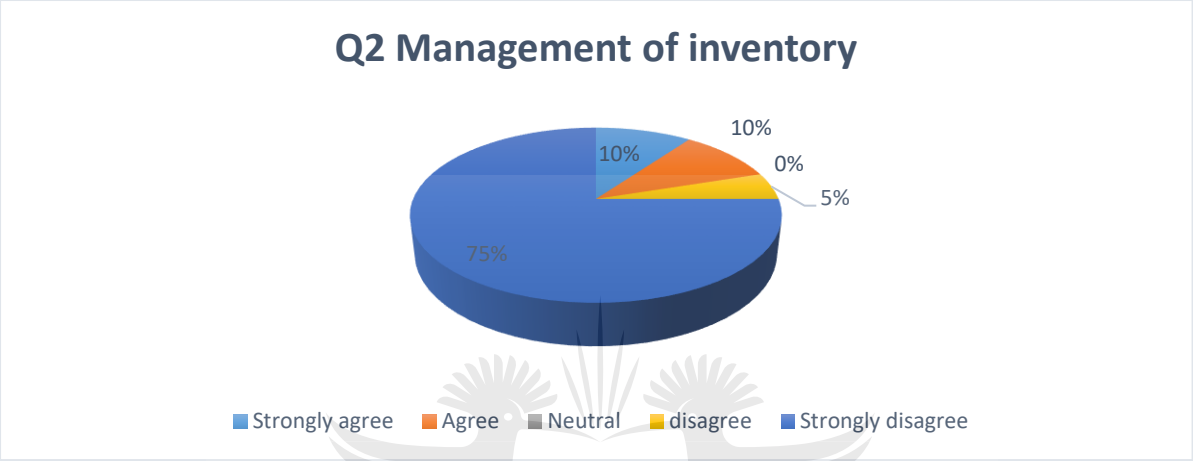

Figure 9: Management of inventory

The question posed in the above figure endeavoured to establish if the inventory is managed effectively. Employees were asked to rate the management of inventory within the case study company. 75% of the employees whom took part in the study strongly disagree that inventory is managed effectively and 5% also disagree. Only 10% of the employees agree and strongly agree that inventory is managed effectively.

- Question 3: Does management take appropriate steps to safeguard goods against risks of theft or loss?

Figure 10: Safeguarding of goods

Figure above indicates the results of the directed question concerning steps by management to safeguard or protect materials from being stolen or damaged; 45% of employees strongly disagree that steps are taken to safeguard the stock or materials, 10% indicated that they disagree that steps are taken to safeguard stock. 15% of the employees are not sure if there are steps taken to safeguard goods. 25% of the employees indicated that they strongly believe that steps are being taken to safeguard the goods, whilst 5% agree that steps are being taken.

- Question 4: Are inventory records regularly reconciled?

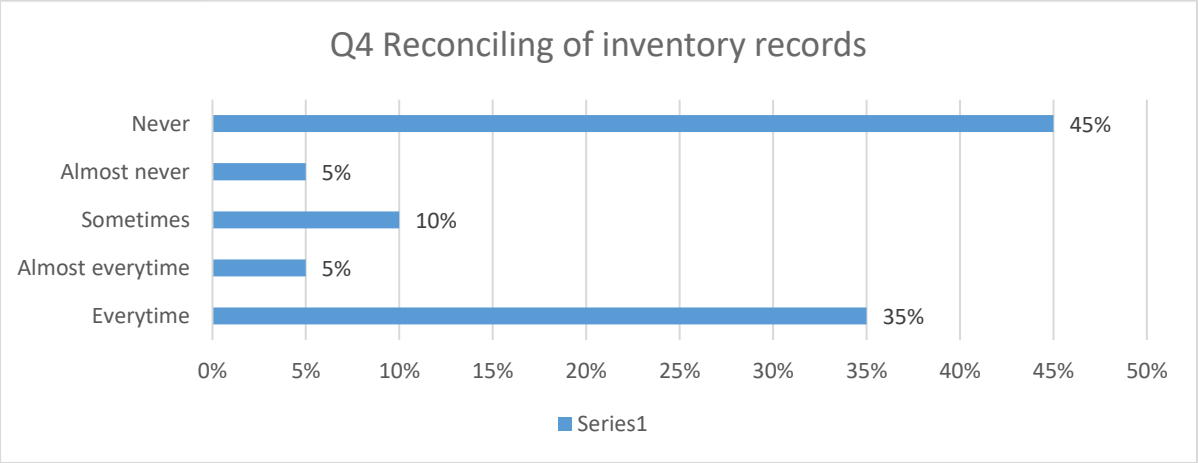

Figure 11: Reconciliation of inventory records

Figure 11 responds to the question concerning regular reconciliation of the inventory records; 50% of employees confirmed that inventory records are not regularly reconciled, whilst 40% of employees confirmed that the inventory records are reconciled; 10% of employees are unsure if the inventory records are reconciled.

- Question 5: Do the warehouse and supply chain compare quantities received against receiving reports?

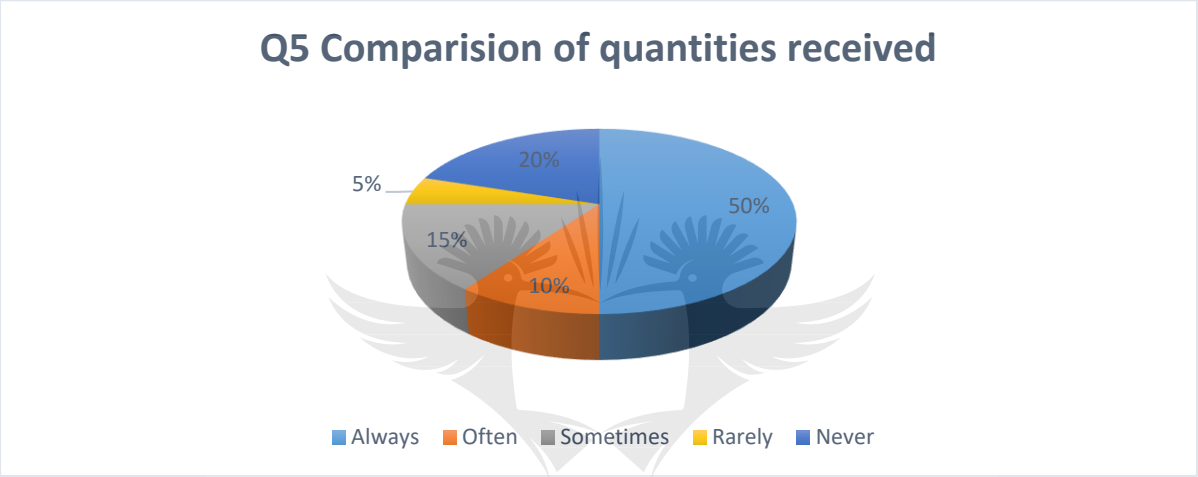

Figure 12: Comparison of quantities received

Figures 12 relates to the quantities of items suppliers delivered to the warehouse. The question directed, intended to verify if the quantities of materials delivered, are checked against the orders on the ERP system; 60% of employees agree that when suppliers deliver materials, SC and warehouse compare the delivered quantities against the ordered quantities; 25% of employees disagree that quantities are compared, whilst 15% of employees are unsure of an occurring comparison.

- Question 6: Are there adequate provisions made for scrap, quarantine and obsol*ete* items?

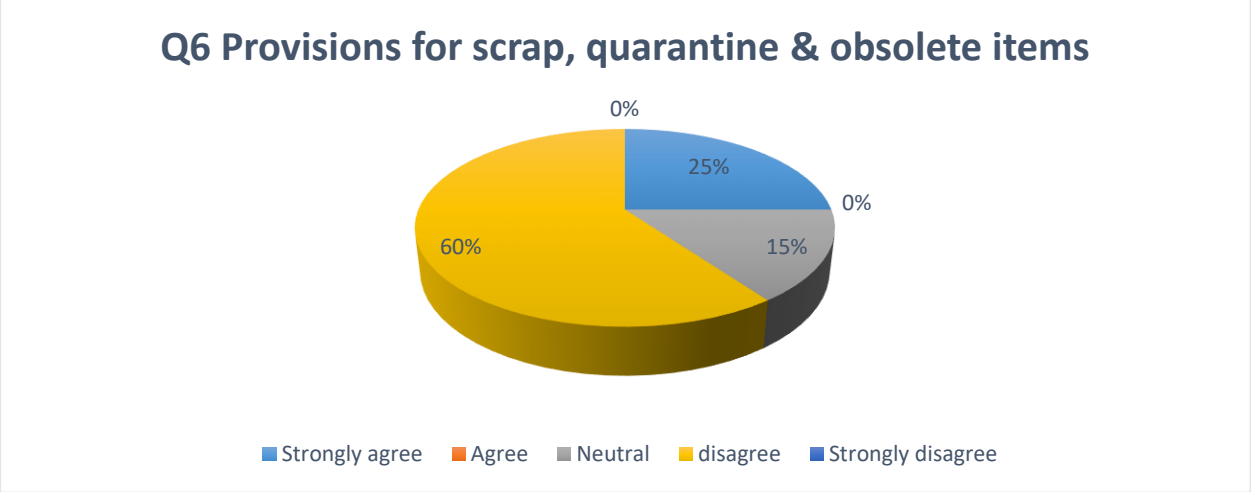

Figure 13: Provisions for scrap, quarantine & obsolete items

Figures above responds to the question relating to the requirements or provisions that should be made for scrap, quarantine and obsol*ete* materials at case study company. The question aims to test if control mechanisms exist for scrap, quarantine and obsol*ete* items. The results indicate that 60% of employees responded that they disagree on the existence of provisions for scrap, quarantine and obsol*ete* material; 15% of employees are unsure if there are provisions, and 25% of employees agree that there are provisions.

- Question 7: Is the process of issuing materials a manual or an automated process, and are there approvals during the issuing process?

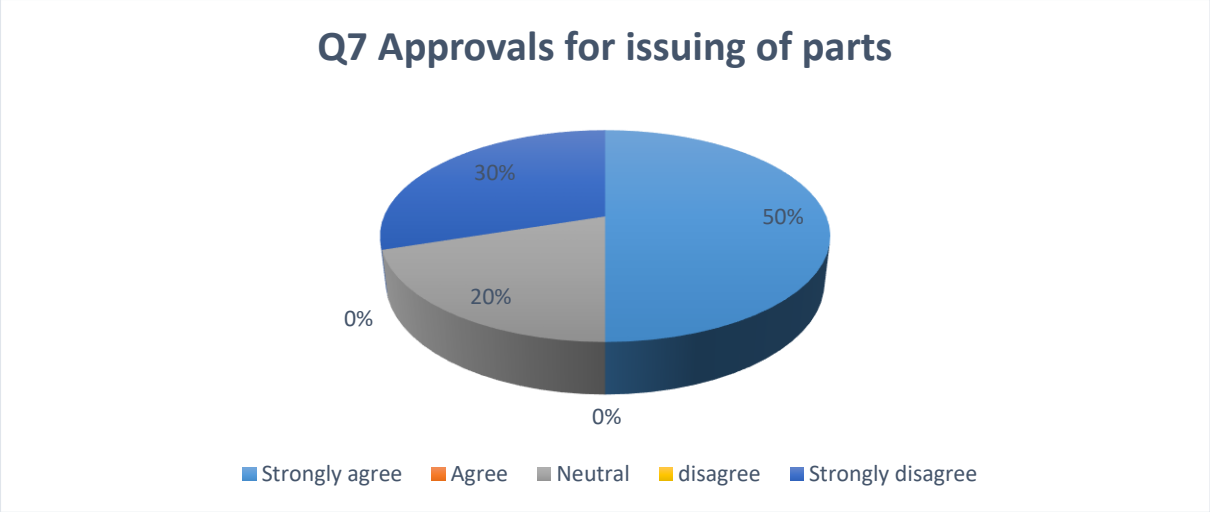

Figure 14: Approvals for issuing of parts

Figure 14 responds to the question concerning the process involved in issuing materials in the warehouse to manufacturing; 50% of employees agree that case study company uses an automated process to issue materials, whilst 30% disagree on the existence of an automated process; 20% are unsure if the warehouse uses a manual or an automated process.

- Question 8: Does management monitor and approve the write-offs of obsolete, scrap and quarantined materials?

Figure 15: Approvals of write-offs

Figure 15 responds to the question regarding management monitoring and approving write-offs of obsol*ete*, scrap and quarantine materials. The results indicate that 55% of employees disagree that management monitors and approves the write-off of obsol*ete*, scrap and quarantine materials; 40% agree that management monitors and approves write-off, whilst 5% are unsure regarding the process.

- Question 9: Is the ABC classification facilitated?

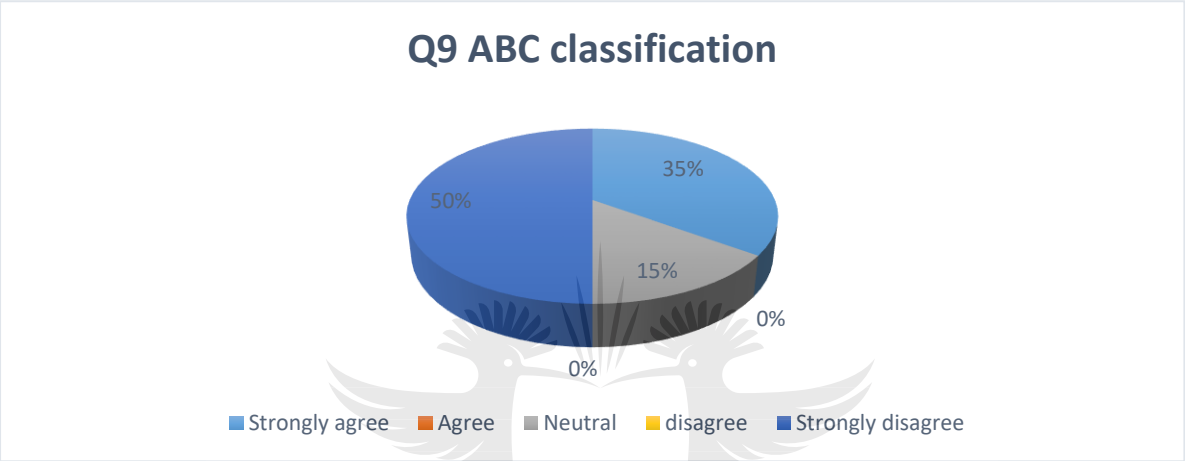

Figure 16: ABC classification

Figure 16 responds to the question concerning a concept by case study company, to assist resolving the inventory and purchasing challenges. Results indicate that most of employees (55%) confirmed that the ABC classification was not facilitated, whilst 35% agree that the ABC classification was facilitated; 15% are unsure if the ABC classification exists in case study company.

- Question 10: Does management review reconciliation physical inventory counts to the inventory records?

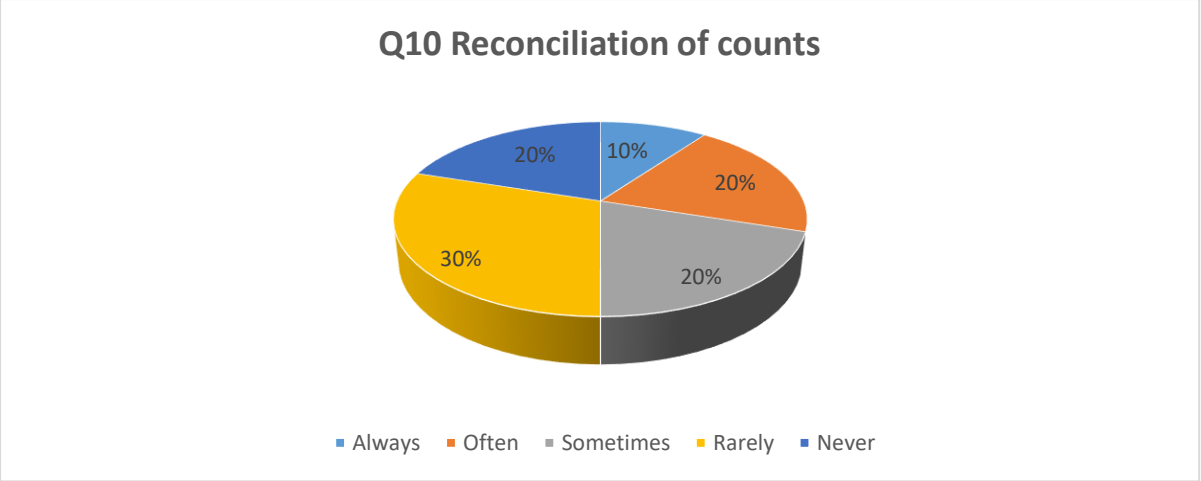

Figure 17: Reconciliation of counts

Figure 17 responds to the question regarding reconciliation physical inventory count to the inventory records of materials in the warehouse; 30% of employees indicated that reconciliation of the physical count to the inventory records rarely occurs, whilst 20% believe the physical inventory count to the inventory records never occurs; 20% indicated that reconciliation occurs sometimes and 20% indicated that it does occur.

- Question 11: Do discrepancies exist between physical counts and the system stock?

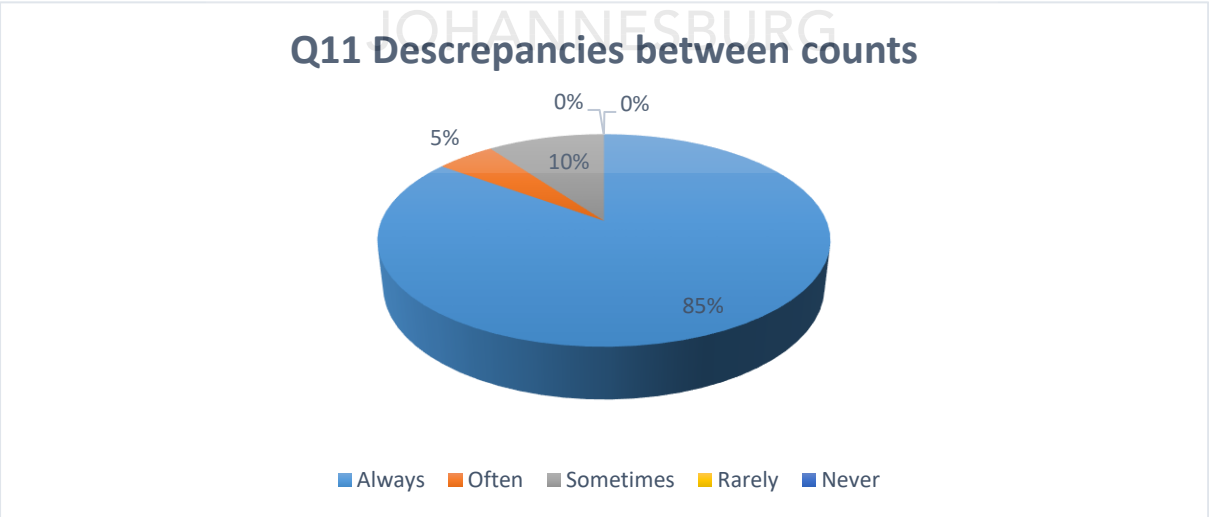

Figure 18: Discrepancies between counts

Figure 18 responds to the question relating to discrepancies b*et*ween physical counts of stock and the stock in the ERP system; 85% of employees confirmed that discrepancies b*et*ween physical counts and the stock system always occur; 5% confirmed that discrepancies often occur and 10% mentioned that discrepancies occur sometimes.

4.3.2 Questionnaires

The questions in the table below were distributed to the identified case study company employees. A scale was used to categorise the answers. The interval of the scale was 1 to 5; 1 represents 'poor' and 5 represents 'excellent'. Employees were requested to rate the plans, processes, policies and facilities in the case study company.

Table 6: Questionnaires table

Line number	**Descriptions**	**Rating Scale**				
		Poor	Fair	Good	Very good	Excellent
1	Military purchase plan	15 75%	1 5%	4 20%	0 0%	1 5%
2	Stock management	15 75%	1 5%	2 10%	2 10%	0 0%

Line number	Descriptions	Rating Scale				
		Poor	Fair	Good	Very good	Excellent
1	Military purchase plan	15 75%	1 5%	4 20%	0 0%	1 5%
3	Warehouse processes	15 75%	0 0%	4 20%	1 5%	0 0%
4	Ordering strategy	15 75%	1 5%	1 5%	1 5%	2 10%
5	Obsolescence policy	17 85%	1 5%	2 10%	0 0%	0 0%
6	Scrap handling policy	2 10%	15 75%	2 10%	1 5%	0 0%

Line number	Descriptions	Rating Scale				
		Poor	Fair	Good	Very good	Excellent
1	Military purchase plan	15 75%	1 5%	4 20%	0 0%	1 5%
7	Quarantine policy	16 80%	2 10%	2 10%	1 5%	0 0%
8	Sales planning policy	1 5%	2 10%	2 10%	15 75%	0 0%
9	Warehouse facility	0 0%	2 10%	17 75%	1 5%	0 0%

Line 1 in the above table indicates that employees were asked to rate the purchase plan at case study company. The questioned posed aimed at establishing if materials are purchased correctly and responsible to me*et* the demand. 75% of employees mentioned that the purchase plan at case study company is poor, indicating that materials are purchased recklessly. Whilst 9% of the employees confirmed that the

purchase plan at case study company is good and it meets the production demand or sales plan.

Line 2 indicates that employees were asked to rate the stock management at case study company. The results indicate that most employees (75%) rated the stock management in the case study poor while 20% of the employees indicated that stock is managed correctly.

Line 3 rates the maturity and correctness of processes within case study company warehouse. Most employees mentioned that processes in the warehouse are b*et*ter and the same number of employees (75%) rated the processes within case study company warehouse poor. 5% of the employees indicated that the warehouse processes are good.

Line 4 deals with the ordering strategies such as EOQ, JIT, make to order and MRP in the case study company. 75% of the employees indicated that the ordering strategies in the case study company are poor, whilst 20% indicated that the current ordering strategies are very good.

Line 5 provide the ratings relating to the obsol*et*e policy at case study company warehouse. The results indicate that the 85% of the employees mentioned that obsol*et*e policy is poor, whilst a few participant (10%) mentioned that the obsol*et*e policy at case study company is good.

Line 6 deals with the concern regarding the scrap handling policy, aimed at controlling scrap materials and costs of scrap materials. From all participants who provided answers, most mentioned that the scrap handling policy is fair with 75% rating, whilst a few participants (10%) mentioned that the scrap policy is good and 10% rated the scrap policy poor.

Line 7 observes the concern on how materials are quarantined at case study company. The results indicate that from participants that answered the question, most employees (80%) mentioned that the quarantine policy at case study company is poor or not working. A few participants (15%) mentioned that the quarantine policy is good and 10% indicated that policy used by the case study company is a fair policy to work with.

In line 8 the sales planning process, participants were requested to rate the process undertaken to create the company sales plan. This process involved data collection, analysis, implementation and monitoring to ensure that the company achieves its targets or goals for a certain period. The results indicate that most participants (75%) agree that the sales planning process at case study company is good and it is one of the processes that works well. Only a few participants (15%) disagreed that the sales planning process is good and rated it 10% fair and 5% poor.

Line 9 answers the question related to the case study company warehouse. It apprehends from the participants if the warehouse facility is in a good or bad condition for storing or for the upkeep of materials. Results indicate that most participants (90%) who answered the question mentioned that the case study company warehouse facility is in a good condition, followed by a few participants mentioning that the warehouse facility is in a bad condition; the other participants (10%) mentioned that the warehouse facility is not that bad or fair.

4.4. Cause and effect diagram

The cause and effect diagram were developed to visualise how various factors associated with the process, affecting the process output (Goetsch and Davis, 2014). The diagram assists to expose and indicate all the possible causes of high inventory levels, discussed with the participants. Employees from production and the warehouse, including projects and managers, were assembled to obtain their observations. These employees participated in the study and they hold a good

apprehending of the inventory topic. Employees used brainstorming to generate the list of possible causes in the cause and effect diagram below.

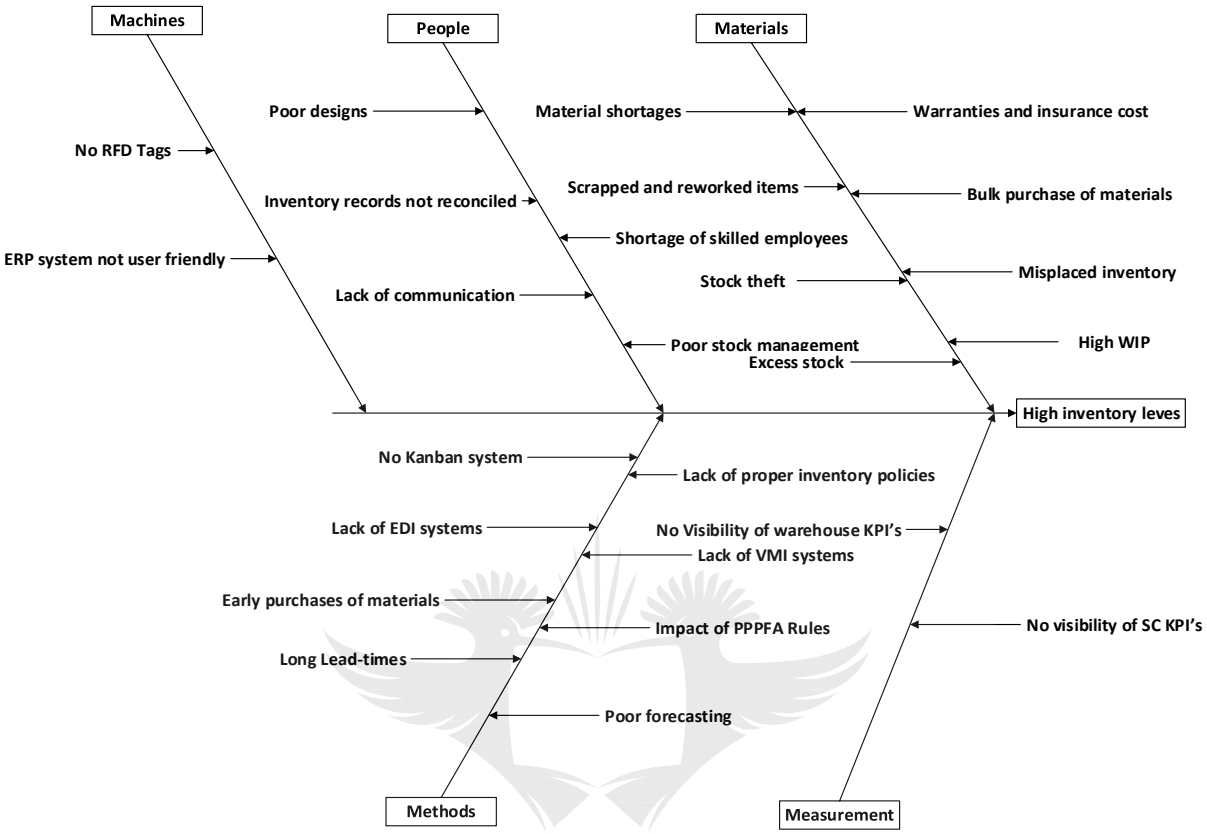

Figure 19: Cause and effect diagram

Causes in Figure 30 above, are explained below.

4.4.1 Machine

RFID tags was emphasised in the literature as a Tool assisting case study company to track and monitor stock. A lack of RFID tags in case study company was emphasised as a reason for misplacing stock and for making it difficult to segregate the good and the bad stock. The ERP system was described as a challenge to case study company employees. The system was described as a system that is slow,

lacking the necessary fields opened to execute work at the warehouse and supply chain departments.

4.4.2 People

Immature data packs and incomplete BOMs were identified as causes of 'cancel order' messages on the ERP system through change request controlled by designers. CR mean that one item can be purchased two times. Qualifications of warehouse employees and project managers were emphasised as a challenge, affecting execution. Participants also mentioned that a department such as SC, must be equipped with technical buyers who apprehend the technical drawings and terms. Currently SC has few employees who poses these skills.

Supply chain officers and supplier relationships were emphasised as a challenge. Participants emphasised the liquidity challenges encountered by case study company, as the main causes. It was emphasised that the communication between case study company and suppliers is damaged to such an extent that suppliers do not want to offer discount anymore.

4.4.3 Materials

Materials were established to be purchased in bulk, meeting the requirements in the ERP system. Materials purchased too early, exposes the company to possible stock theft and losses, attributable to damages in the warehouse. It was also mentioned that warrantees on certain of the items expired. Stock excess was also emphasised as a challenge in case study company. Reasons provided for the stock excess is that several suppliers prefer to supply their stock in batches higher than the required stock. Insurance costs are high, attributable to stock stored in the warehouse for several months. Scrap, quarantine and obsolete materials are not effectively managed. It was mentioned that certain scrapped, quarantined and obsolete stock were combined with usable stock. Misplaced stock is a concern as it is time consuming to trace. If it is not

found, new stock has to be purchased. Stock theft and stock were emphasised as impacting on material shortages. A high WIP was identified as a reason for a high stock level because of the shortages of materials required to complete work orders.

4.4.4 Methods

There are no visible procedures, policies and guidelines, for managing the inventory at case study company. Policies such as EOQ economic stock were not found. Rules and policies such as PPPFA, prolong the ordering process. Lead-times of the tenders were emphasised as a major concern because SC officers consume more than seven months to complete a tender and to place an order. Investigations established a lack of systems, such as VMI and EDI to manage the supply chain and suppliers during orders and manufacturing phases of order materials from suppliers. There were no visibility of tools, such as a Kanban system in the warehouse and production area. Forecasting methods for the sales and inventory was emphasised as a major challenge.

4.4.5 Measurement

KPIs were not visible and it was difficult to measure and manage stock turnover and movement.

4.5. Triangulation

According to Runeson *et al.* (2012), as discussed in Chapter 3, triangulation deals with multiple sources of information or a study perspective to provide an improved representation of the study conducted. Table 8 compares the literature, operational data and questionnaire to validate the findings of the research. A symbol ‘X’ marked the factors appearing on literature, operational data and questionnaires.

Table 7: Triangulation

Factors causing high inventory levels	Literature	Document review	Questionnaire
Mismatch between procurement plan and sales plan	X	X	X
Misplaced stock	X		
Design changes	X	X	X
Overproduction	X	X	X
Inventory costs	X		X
Obsolescence	X		X
Scrapped materials	X	X	X
Quarantines stock issues	X		X
Ordering strategy	X	X	X
Inventory inaccuracy	X	X	X
Inconsistent lead-times	X		X
Lack of policies (SC and warehouse)	X		X
High WIP	X	X	X

Cross comparison in Table above indicated that the factors below, appeared in literature, document review and questionnaires:

- Mismatch between purchase plan and sales plan
- Design changes
- Overproduction
- Scrapped materials
- Ordering strategy
- High work in process

The factor below appeared in literature and questionnaires:

- Inventory costs
- Quarantine stock issues
- Inconsistent lead-times
- Lack of policies

The factor listed below appeared in literature:

- Misplaced inventory

4.6. Conclusion

The main aim of this research was to gain an understanding of the causes of high inventory levels at case study company. Chapter 4 presented operational data and questionnaires. Triangulation was conducted whereby factors in literature, operational data and questionnaires were compared. Based on the information presented in the triangulation the following factors listed below appear in all three areas, literature, document review and questionnaires:

- Mismatch between purchasing and sales plan
- Design changes
- Overproduction
- Scrapped materials
- Ordering strategy
- High work in process

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The study was conducted in the Case study company, a military company producing various types of military products. Over the past seven years, case study company top management reported on high inventories, compared to the sales and inventories of additional years. Inventory adopts a form of raw materials, WIP and semi-finalised or finalised products (He, 2013). Goetsch and Davis (2014) identified three types of inventories: (1) Inventory of raw materials required for production. (2) The WIP inventory of semi-finalised goods. (3) The finalised goods inventory. This study introduced the research m*et*hods, research approach and research strategies used to collect data and to answer the research questions. Qualitative and quantitative m*et*hods were used. A cause and effect diagram were developed to visualise how various factors associated with the process, affect the process output (Goetsch and Davis, 2014). The diagram assists to expose and indicate all possible causes of high inventory levels discussed with the participants.

Employees from production, warehouse, projects and management convened to provide their perceptions. These employees participated in the study and they have a good understanding of the inventory topic. Chapter 5 discusses the findings and the recommendation, based on the literature, operational data and questionnaires discussed in the previous chapters. The study sought to investigate the causes of high inventory levels in case study company.

5.2 Findings

The research objectives of this study endeavoured to uncover root causes of inventory levels. The study suggests solutions to the root causes.

The research questions below, endeavoured to achieve the aforementioned objectives:

- What are the causes of the high inventory levels in case study company?
- What are the mitigation plans and controls that can assist reduce inventory?

The answer to the first question is:

The following factors were identified as the cause of high inventory levels at case study company:

- Mismatch between purchasing and sales plan
- Overproduction
- Scrapped materials
- Ordering strategy
- High WIP

Answer to the second question:

The factors listed below answer the second question with the references:

- Mismatch between purchasing and sales plan: Effective and efficient sales, production and inventory strategies should be devised and monitored regularly (Gang *et al*., 2012). Sales plans must be stabilised, action messages must be managed regularly, with optimal acquisition and inventory control (Jiang *et al*., 2013).
- Design changes: Qualified employees who take ethical issues seriously during design should be given tasks handle the design tasks (Runeson *et al*., 2012). Design changes are costing case study company lot of money as demontrated in the previous section.

- Ordering strategy: By facilitating proper EOQ policies in case study company and maintaining good relationships with suppliers to negotiate on the supplied quantities and prices (Lopez *et al*., 2013).
- Overproduction: Using tools such as Kanban will ensure that the case study company manufacture what is needed or required (Goetsch and Davis, 2014)
- Scrapped materials:
- High WIP: Optimisation of production and using a Kanban system to control and monitor movement of material, will assist reducing WIP (Gurgur, 2013).

5.3 Recommendations

Recommendations are based on the findings discussed in Section 5.2. The suggestion below, are based on the best adopted practices, with references from the literature:

- Inadequate planning is identified as a main cause for inventory levels, appearing within several sections of this research. Management should spend more time aligning projects, sales, purchases, production and inventories. Effective and efficient production and inventory strategies should be facilitated (Gang *et al*., 2012).
- Management should update and craft effective policies, assisting the supply chain to purchase materials responsibly. The warehouse should manage the inventory effectively (Sun *et al*., 2013). Policies will also assist to monitor and control extra stock or excess stock, attributable to batch orders, suppliers enforced in their contracts (Lopez *et al*., 2013).
- Management should consider purchasing and utilising RFID tag technology to manage, monitor and protect the warehouse from stock theft (Zhang *et al*., 2014).
- Management should employ systems, such as Kanban and a pull system to minimise inventory holding, reducing WIP in production (Apreutesei *et al*., 2010).
- VMI system and ABC classification combined with EDI, are important systems that management should facilitate at case study company to improve coordination and

communication channels between case study company and suppliers, ensuring tracking of orders movements (Rodriguez and Vidal, 2009).

5.4 Future research

The research concerns high inventory levels, demonstrating that the inventory topic is crucial, and a further d*et*ailed research is required to gain more insight concerning inventory and the areas it affects. This research indicated that extreme inventory levels can be caused by several factors within an organisation. A clear strategy, coupled with a good understanding of the organisation where the research will be conducted, is essential.

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APPENDIX A: MOTIVIATIONAL LETTER

MEMORANDUM

To : Acting CEO, CASE STUDY COMPANY

From : Sipho Ngunyule

Acting Executive Manager: Business Excellence

Date : 3 July 2018

Subject: PERMISSION TO CONDUCT RESEARCH ON INVENTORY LEVELS IN CASE STUDY COMPANY

BACKGROUND

I am currently studying MPhil in Engineering Management through the University of Johannesburg and Denel is financing my studies. I started my MPhil in Engineering in 2017 and I am currently busy with Minor Dissertation. My topic is based on the management and control of inventory in the military sector. My topic was approved early this year and my supervisor is Dr H Nel. During our meeting with Dr Nel, she mentioned that I must obtain approval from Denel Management to conduct my research within the company. The reason she mentioned this as a requirement, is to ensure that the information between Denel and University of Johannesburg is protected and confidential and ensuring that the company provides me with the information I require for this research.

WHAT WILL THE RESEARCH OFFER?

The research will provide Denel Land System with an opportunity to have one of its employees to conduct a thorough study on the area that was a real thorn to top management. For the past 3 years, inventory levels in Denel Land System was high, hovering around R700m and R1.2bn. The main objective of this research is to highlight, with evidence, all the areas in Denel Land System that cause the inventory to be high and provide possible solutions to minimise and control inventory.

The study, adversely, is intended to equip me with good knowledge on inventory management challenges and to ensure that I obtain my qualifications. This qualification will be definitely ploughed back to the organisation. I were involved in several projects that relate to the inventory levels, although we did not dive deep into the real causes of high inventory levels for various reasons.

REQUEST

Based on the aforementioned statements, I humble request the CEO of Case study company to grant permission to allow me to conduct the research and to obtain the information within Case study company, that is required to assist in this study.

The information that will be required comprises:

1) Sales graphs and Sales figures

2) Inventory information

3) Financial information

4) WIP information

5) MPS information

6) Other information that might be deem necessary for the study

Prepared by:

_____ _____

(Original signed)

Sipho Ngunyule Date

ACTING EXECUTIVE OFFICER: BUSINESS EXCELLENCE

APPROVED / REJECTED

_____ _____

(Original signed)

Ismail Dockrat Date

ACTING EXECUTIVE OFFICER: CASE STUDY COMPANY

APPENDIX B: **DELIVERY SCHEDULE**

	Totals		2018/19										
		A	M	J	J	A	S	O	N	D	J	F	M
Platforms	0												
Turrets	6										4	2	
		2019/20											
		A	M	J	J	A	S	O	N	D	J	F	M
Platforms	9							1	1	1	1	2	3
Turrets	23				1	2	3	3	3	3	3	4	1

		2020/21											
		A	M	J	J	A	S	O	N	D	J	F	M
Platforms	35	3	4	1	2	3	3	3	3	3	3	4	3
Turr*et*s	35	2	3	3	3	3	3	3	4	3	3	4	1
		2021/22											
		A	M	J	J	A	S	O	N	D	J	F	M
Platforms	35	3	4	1	2	3	3	3	3	3	3	4	3
Turr*et*s	35	2	3	3	3	3	3	3	4	3	3	4	1

		2022/23											
		A	M	J	J	A	S	O	N	D	J	F	M
Platforms	35	3	4	1	2	3	3	3	3	3	3	4	3
Turr*et*s	35	2	3	3	3	3	3	3	4	3	3	4	1
		2023/24											
		A	M	J	J	A	S	O	N	D	J	F	M
Platforms	35	3	4	1	2	3	3	3	3	3	3	4	3
Turr*et*s	34	2	3	3	3	3	3	3	4	3	2	4	1
		2024/25											

		A	M	J	J	A	S	O	N	D	J	F	M
Platforms	35	3	4	1	2	3	3	3	3	3	3	4	3
Turr*et*s	34	2	3	3	3	3	3	3	4	3	2	4	1
		2025/26											
		A	M	J	J	A	S	O	N	D	J	F	M
Platforms	35	3	4	1	2	3	3	3	3	3	3	4	3
Turr*et*s	16	2	3	3	3	3	2						
		2026/27											
		A	M	J	J	A	S	O	N	D	J	F	M

Platforms	4	3	1										
Turr*et*s	0												
Platforms total	223		Stock	21		Total	244						
Turr*et*s Total	218		Stock	5		Total	223						

Notes

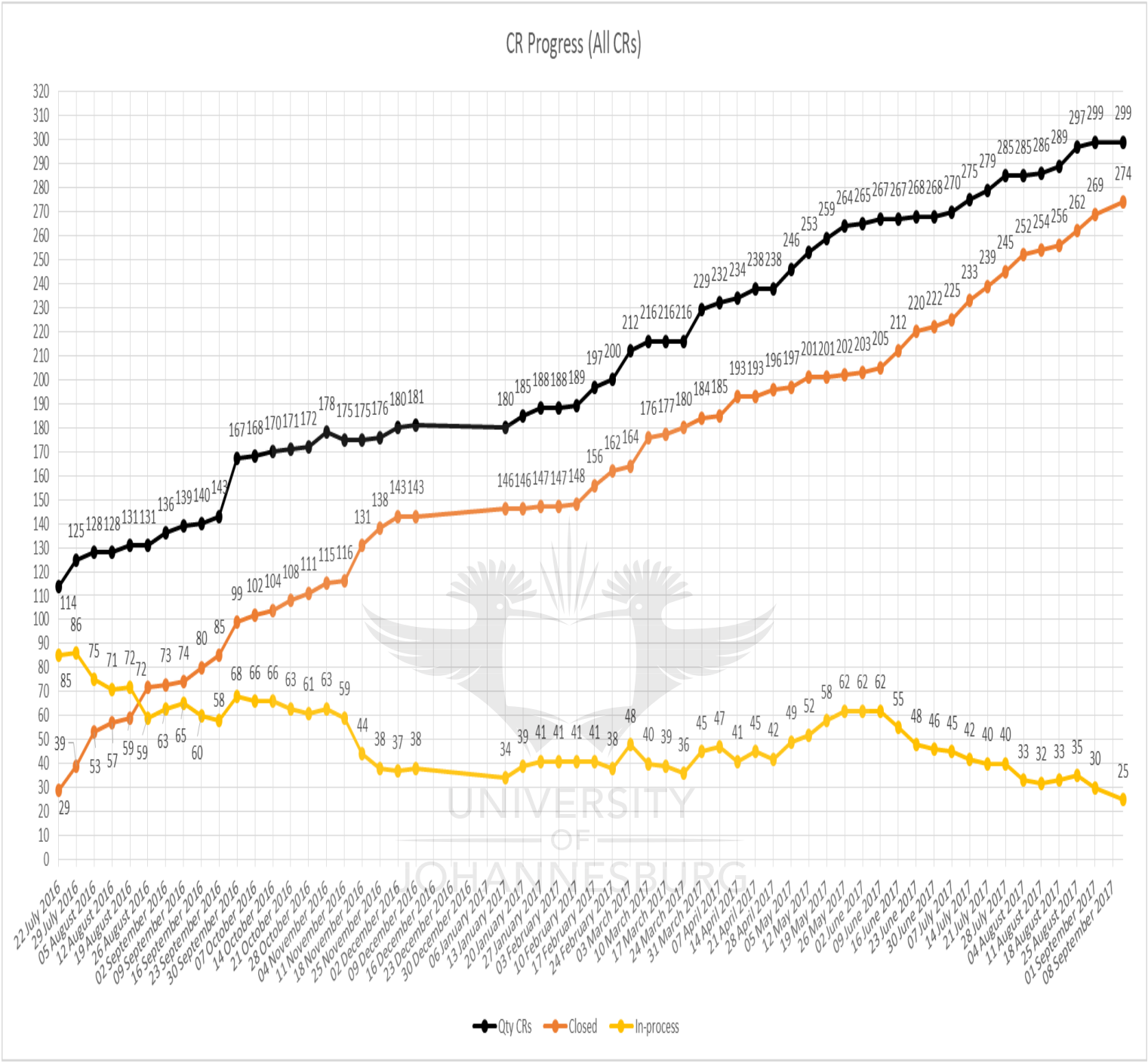
These are delivery dates to Armscor

Turr*et* Components required 2.5 months in advance

21 Systems do not require Turr*et*s

APPENDIX C: PRODUCT A SECTION VARIANT CHANGE REQUEST DATA

Date	Qty CRs	Closed	In-process	Approved	NOT Approved	
22 July 2016	114	29	85	29	56	
29 July 2016	125	39	86	36	50	
05 August 2016	128	53	75	24	51	
12 August 2016	128	57	71	22	49	
19 August 2016	131	59	72	27	45	
26 August 2016	131	72	59	18	41	
02 September 2016	136	73	63	26	37	
09 September 2016	139	74	65	30	35	
16 September 2016	140	80	60	24	36	
23 September 2016	143	85	58	20	38	
30 September 2016	167	99	68	22	46	CRs implemented between 2016-01-06 and 2016-07-22 now also included. CRs in process of being registered (i.e. SE and other roleplayer not yet assigned) now also included.
07 October 2016	168	102	66	21	45	
14 October 2016	170	104	66	18	48	
21 October 2016	171	108	63	23	40	
28 October 2016	172	111	61	21	40	
04 November 2016	178	115	63	25	38	
11 November 2016	175	116	59	37	22	Two issues on which no design changes will be implemented (marked N/A) are excluded from the total CR count. Duplicated CR removed from the list.
18 November 2016	175	131	44	22	22	Request to provide hook for the gunner's helmet was marked N/A (i.e. no longer required) and are excluded from the total CR count.
25 November 2016	176	138	38	18	20	
02 December 2016	180	143	37	14	23	
09 December 2016	181	143	38	15	23	
13 January 2017	180	146	34	14	20	No action will be taken on the change request to increase the spacing between characters on the battle panels (i.e. marked "N/A"). The font size was increased to improve the legibility.
20 January 2017	185	146	39	14	25	
27 January 2017	188	147	41	13	28	
03 February 2017	188	147	41	15	26	
10 February 2017	189	148	41	24	17	
17 February 2017	197	156	41	25	16	
24 February 2017	200	162	38	21	17	
03 March 2017	212	164	48	21	27	
10 March 2017	216	176	40	22	18	6 CRs on Turret-Platform harnesses were previously listed as part of the "Turret CRs" but these harnesses are now listed as part of "Other CRs".
17 March 2017	216	177	39	22	17	
24 March 2017	216	180	36	19	17	
31 March 2017	229	184	45	19	26	
07 April 2017	232	185	47	23	24	
14 April 2017	234	193	41	15	26	
21 April 2017	238	193	45	18	27	
28 April 2017	238	196	42	17	25	
05 May 2017	246	197	49	17	32	
12 May 2017	253	201	52	16	36	
19 May 2017	259	201	58	16	42	
26 May 2017	264	202	62	19	43	
02 June 2017	265	203	62	21	41	
09 June 2017	267	205	62	21	41	
16 June 2017	267	212	55	21	34	
23 June 2017	268	220	48	21	27	
30 June 2017	268	222	46	23	23	
07 July 2017	270	225	45	20	25	The design changes on the Miscellaneous Bin (punch holes instead of laser cut) and the Basket (drill holes in basket leg for CV MW Ammo Bin) were removed from this list. These design changes will be implemented if and when required.
14 July 2017	275	233	42	21	21	
21 July 2017	279	239	40	19	21	
28 July 2017	285	245	40	19	21	
04 August 2017	285	252	33	15	18	
11 August 2017	286	254	32	17	15	
18 August 2017	289	256	33	16	17	
25 August 2017	297	262	35	15	20	
01 September 2017	299	269	30	14	16	
12 September 2017	299	274	25	13	12	No new CRs were added to the list after 1 September 2017.



APPENDIX D: PRODUCT A TURR*ET* DELIVERY PURCHASE AND PRODUCTION PLAN FOR 2017/2018

Turret delivery		2017/18												2018/19											
		April	May	June	July	August	Septem	Octobe	Novem	Decem	January	Februa	March	April	May	June	July	August	Septem	Octobe	Novem	Decem	January	Februa	March
CV PPM	2				2																				
MV PPM	2																2								
MslV PPM	2																	2							
SV PM	45				5	6	7	7	7	2	4	7													
FSV PM	6												6												
CV PM	19												2	4	6	7									
MslV PM	6																							2	4
MV PM	12																		1	4	4	2	1		

Component delivery																									
	Total	April	May	June	July	August	Septem	Octobe	Novem	Decem	January	Februa	March	April	May	June	July	August	Septem	Octobe	Novem	Decem	January	Februa	March
CV PPM	2	2																							
MV PPM	2													2											
MslV PPM	2														2										
SV PM	45	5	6	7	7	7	2	4	7																
FSV PM	6									6															
CV PM	19									2	4	6	7												
MslV PM	6																				2	4			
MV PM	12															1	4	4	2	1					

APPENDIX E: PRODUCT A COMMON PLATFORM PURCHASE AND PRODUCTION PLAN

	Oct 2017	Nov 2017	Dec 2017	Jan 2018	Feb 2018	Mrch 2018	April 2018	May 2018	June 2018	July 2018
Sale (based on Common Platforms)							4	4	7	8
Ready for presentation (1 month between presentation and sale)						4	4	7	8	
HW to DVS to start assy (3 months lead time)			4	4	7	8				
Value of items on 1 Common Platform	R 12,629,794		R 50,519,176	R 50,519,176	R 88,408,558	R 101,038,352	**R 290,485,262**			
							Total			
Sale (based on Turrets)							2	3		
Ready for presentation (1 month between presentation and sale)						2	3			
HW to DLS to start assy (1 month lead time)					2	3				
Value of items on 1 SV Turret	R 5,410,771				R 10,821,542	R 16,232,313	R 27,053,855			**R 317,539,117**
							Total			Grand Total