

Arena Simulation of Spare Parts Inventory Management: A Case of A Telecom Managed Service Provider

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Abstract

Telecommunications and utilities companies, among other large service organisations, confront a slew of decision-making challenges, many of which are connected to the management of a variety of different resources. The management of spare parts and inventories is one of the most difficult resource management concerns that an organisation has to deal with on a regular basis. Their prompt availability may have a significant influence on the overall quality of the service and the level of client satisfaction. The purpose of the study was to assess the Spare Parts Inventory Management of XYZ company operating within the Ghanaian telecommunication ecosystem. Data on demand and inventory stock level was collected from the procurement department of XYZ company. The study adopted the use of the Arena Simulation model to analyze data collected from the XYZ company. The results of the analysis indicated that the procurement department is unable to meet the spare parts demand of the Passive department where the average order received from the department in a day is 6.08. Based on the findings of the study, it is recommended that the procurement department put in measure to receive and process orders in time. The reason for the delay in processing orders could be the less poor inventory management practices of the company. The study recommends that systems be adopted to track the inventory level of the company. Due to the stochastic nature of the demand from the passive department, the company should be proactive in the management of the demand by keeping the right stock level in order to meet the demand of the department in order to reduce the long down time.

Key words: Spare parts, inventory, Arena Simulation, telecommunication

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1. Introduction

Maintenance expenses may be more readily managed and lowered when maintenance planning is used. When it comes to maintenance expenses, they encompass not only the price of personnel and spare parts (Chen et al., 2015), but also the costs of equipment downtime as a result of equipment failure. Because it has an impact on the downtime of equipment in the passive telecommunications industry, an efficient and effective spare parts management system is vital for maintenance management in this sector. So, the administration of operational equipment replacement parts influences the performance of maintenance management and, as a result, the Service Level Agreements (SLA) that businesses provide to their customers and clients. High availability and dependability of operating equipment are necessary in businesses that rely heavily on their equipment to function properly. As a result, spare parts are a valuable resource for ensuring continuous availability (Roda et al., 2014).

Spare parts inventory management has the capability of assisting in the provision of maintenance services, such as ensuring the operability of the systems that have been installed. Maintaining large inventories of spare parts, on the other hand, is a crucial problem since it requires a big amount of capital and often results in related expenses accounting for a significant portion of capital investments (Kennedy et al., 2002). Spare parts are used in a large number of maintenance interventions, and the inventory costs associated with them can be divided into two categories: inventory costs associated with holding stock and inventory costs associated with the non-existence of a spare part associated with operation stoppages. In many ways, spare parts inventories differ from inventories of finished goods and raw materials (Kennedy et al., 2002). A substantial cost magnitude is associated with spare parts, as is intermittent and extremely irregular demand. Spare parts stocks are governed by demand, which is triggered by preventive and corrective maintenance actions.

To minimise the likelihood of equipment failure, significant downtime, and high costs, the availability of replacement parts should be tightly linked to maintenance schedules. Inventory and maintenance management must be seen as interrelated components that work together to optimise a company's operations (Van Horenbeek et al., 2013). Maintenance management systems (CMMS) are now a critical component of many firms' maintenance departments, and they provide assistance with a wide range of operations that are associated with maintenance. In terms of spare parts, they can follow the flow of spare parts as well as their requisitioning when required (Labib, 2004), and they can make the integration of logistics and maintenance perspectives more simpler (Cavalieri et al.,2008). Maintenance planning and execution will be more efficient as a result of the integrated logistics and maintenance decision-making process. Scholars such as Molenaers et al. (2012) have said that the effective management of spare parts is a crucial study subject because of the financial resources and service needs associated with the process.

The primary goal of maintaining inventory is to be able to provide components and materials whenever there is a demand for them (Williams and Tokar, 2008). As a result, the demand process plays a significant role in the development of the supply process and the management of inventories (Williams and Tokar, 2008.). Depending on the assumptions made, either the demand rate is known and constant, or the demand rate is unknown and not constant, the procedure for determining demand is carried out (Williams and Tokar, 2008.). However, the need for spare parts is sporadic, occurring seldom and at times displaying no demand at all, but the desire for new components is constant (Turrini and Meissner, 2017). Due to the fact that events occur constantly and independently at a constant average rate, the operational lives are exponentially dispersed in this case (Williams and Tokar, 2008.). Based on these assumptions, the firm must establish parameters for the optimal order quantity, order point, and safety stock, which will define the amount of stock maintained on hand and the value of that stock (Braglia et al., 2004). When attempting to lower the number of spare parts held in inventory by establishing low order points and safety stocks, the firm must ensure that the availability and accessibility of spare parts will not increase the amount of downtime experienced in the event of a failure or breakdown. Because each time unit of downtime is expensive, unavailability must be avoided at all costs. As a result, there is a difficult trade-off between the costs of spare parts storage and the costs of unavailability. Despite the fact that holding costs are high, businesses will suffer a higher financial loss as a result of the cost of downtime, and as a result, they will prefer to retain a large number of components in stock at all times (Wong et al., 2007; Lin et al., 2017).

Parts management is strongly dependent on the asset's lifespan, which is impacted by the environment in which it is located (Durán et al., 2016). The failure rate and maintenance policies will have an impact on the consumption rate of spares, and management will attempt to set inventory rules based on these factors (Durán et al., 2016.). The failure rate of an asset is generally viewed via the notion of the bathtub curve, in which failures are classified as decreasing, constant, or rising in frequency (Durán et al., 2016). Organizations repair, replace, and maintain components that have failed in order to cope with the failure.

Telecommunications and utilities companies, among other large service organisations, confront a slew of decision-making challenges, many of which are connected to the management of a variety of different resources. The management of spare parts and inventories is one of the most difficult resource management concerns that an organisation has to deal with on a regular basis (Shakya et al., 2017). Their prompt availability, in particular, may have a significant influence on the overall quality of the service and the level of client satisfaction. A lack of visibility and availability of replacement parts in the appropriate location and at the appropriate time might result in a longer trip distance to provide the parts or, in the worst-case scenario, an interruption of service for the customer. A motivation for this study comes from the work of Samad and Anand (2016), who hypothesized the need for more research on the simulation of inventory goods in a warehouse in order to maximise their inventory level while minimizing costs and stock out.

There is a considerable wait time at the XYZ firm since replacement parts were purchased from a single central warehouse in the national capital, and there was no local warehouse available. Stock out costs result in a high mean time between failures (MTTR), which results in customer complaints, expensive fines, and a loss of reputation in the sector. Furthermore, it has been discovered that the minimum and maximum levels of inventory at XYZ were not properly regulated, as certain components were stored in excess while other parts were placed below the necessary level of inventory. The XYZ firm is experiencing a significant issue with outdated spares and non-moving things, since certain components are deteriorating on the shelf and non-moving items are accounting for a significant portion of the inventory cost. Inventory documentation at XYZ firm was not kept up to date in a timely manner.

In Ghana, the XYZ firm serves as an international service provider to multinational telecommunications corporations (MNCs). Activity areas include passive telecom infrastructure, active telecom infrastructure, as well as the construction of towers for tower companies that operate in this country. It has a large warehouse at its headquarters and smaller holding warehouses in its numerous operational sites around Ghana, where spare components that have been relocated from Accra are held for emergency usage. Because the company's operating areas are located far away from their headquarters and because they have signed an SLA that requires them to maintain the reliability of the telecom equipment they manage, a prolonged mean time between failures (MTTR) is punished by the operator, who charges the company a surcharge. If, for example, a generator breaks down and requires extensive repairs, components must be sent from the warehouse in Accra to the area, and it might take up to 24 hours before the replacement part is obtained. The procurement department of XYZ firm is in charge of managing the company's warehousing facilities. Restocking is carried out on the basis of expert knowledge and requests from the many departments that utilise the product. It is critical to examine the inventory management of spare parts at the firm XYZ since the company has seen many equipment failures in recent months, resulting in a lengthy mean time between failures (MTTR) to restore the cell sites owing to a lack of spare parts.

2. Theoretical Review

2.1.1 ABC analysis of Spare Parts Inventory

The most often used "tools" for spare component categorization have traditionally been basic and uncomplicated techniques such as quantitative ABC (Pareto-like) and qualitative vital, essential, and desirable (VED) analysis. ABC classification, which divides inventory goods into three classes (A, B, and C class), has traditionally been based on a single criterion: for inventory items, this is often the yearly dollar utilisation of the spare item (Partovi and Burton, 1993). ABC analysis based on a single criterion is simple to do and is ideally suited for inventory management of commodities that are relatively homogeneous in nature, with the only differences between them being the unit price and demand volume. In order to target control efforts without the requirement for item-specific analysis, ABC analysis has kept its appeal in recent years (Flores and Whybark, 1985; Zhou and Fan, 2007). It is widely acknowledged that a "classical" ABC analysis may not be capable of providing a suitable classification in reality for spare parts inventory management (Guvenir and Erel, 1998; Partovi and Anandarajan, 2002; Celebi et al., 2008).

2.1.2 The Vital, Essential and Desirable Classification of Spare Parts Inventory Management

It is commonly known that the VED categorization (Mukhopadhyay et al., 2003) is a qualitative system that is based on consultation with maintenance specialists. Following their comments, spare components are classed as vital (V), essential (E), and desired (D) products, with vital being the most important. However, despite its apparent simplicity, designing a VED study may be complex, since its completion may be hampered by the subjective opinions of the users (Cavalieri et al., 2008). In accordance with Duchessi et al. (1988), established procedures for categorising spare parts often need the subjective evaluation of the relevance of spare parts by engineers, materials managers, quality control workers, or other specialists. This may be acceptable since the assessors have extensive expertise; nonetheless, there may be dispute about the genuine significance of a particular element.

As a result, a more rigorous strategy based on factual facts is better in this situation. More recently, the trend indicates that academics are beginning to evaluate the importance of taking into account characteristics that are not readily quantifiable, either because of the challenges in gathering appropriate data or because of the difficulty in defining the component itself. The research discussion revealed that a well-structured classification of spare parts cannot be based on just one single criterion, nor on only qualitative judgments or only quantitative measures; the need for a multi-criteria perspective on classifying spare parts was first revealed in the literature during the course of the research discussion.

2.1.3 A Multi-Criteria Classification of Spare Parts Inventory Management

Flores and Whybark (1985) provided a cross-tabulate matrix technique for applying the bi-criteria approach in order to classify spare parts, which was the first suggestion mentioning a bi-criteria approach in order to classify spare parts in the first place. As the original point of reference, this work has sparked subsequent debates over some of the downsides. For example, as noted by Celebi et al. (2008) and Ng (2007), it becomes problematic to utilise the same criterion for more than two criteria at the same time.

Some more multi-criteria classification approaches are proposed by researchers like Nagarur et al. (1994) and Porras and Dekker (2008), who offer a hierarchical two- or three-dimensional qualitative and quantitative categorization system. A step further, Ramanathan (2006) suggested the use of a weighted linear optimization model for the implementation of a multi-criteria ABC classification system. It is possible that the model will have limitations since each item must undergo linear optimization, and the processing time may be quite lengthy when the number of things is big, such as when the number of items is in the thousands (Ng, 2007). Furthermore, Zhou and Fan (2007) proposed an additional strategy to address another issue with Ramanathan's model: the possibility that the model might result in a scenario in which an item with a high value in an irrelevant criterion is erroneously classed as a class A item. Utilizing an algorithm for a multi-criteria classification, Ng (2007) attempted to solve the difficulty of using an optimization model to identify weights for each criterion by developing an algorithm for a multi-criteria classification that converted all the measurements of an inventory item into a scalar score. By using a nonlinear programming model to generate an overall set of weights for all of the spare items before continuing with an ABC classification of the obtained scores, Hadi-Vencheh (2010) improves on Ng (2007)'s technique, which was previously described. Although the approach is straightforward to develop, it has certain limitations in terms of its applicability due to the fact that it can only be used with continuous-type criteria. Liu (2006) used the same technique to handle ABC inventory categorization, presenting a reduced data envelopment strategy that relied on a linear programming model that was used frequently, as well as applying simulated examples to evaluate the efficiency of the model, as described above. When the number of spare parts is large, the model suffers from the same drawbacks as the optimization models provided by other authors in terms of application complexity, which is a disadvantage.

A novel inventory management technique, ABC fuzzy classification, was presented by Chu et al. (2008), and it can handle variables having either a nominal or a non-nominal (that is, quantitative) characteristic. The approach is described in detail below. In addition, several other meta-heuristics have been proposed in the scientific literature for the classification of multi-criteria inventory items, including genetic algorithms (Guvenir and Erel, 1998; Marseguerra et al., 2005), artificial neural networks (Partovi and Anandarajan, 2002), and particle swarm optimization (Guvenir et al., 2005; Tsai and Yeh, 2008). Despite this, the application of these methodologies to real-world industrial situations is quite limited.

The analytical hierarchy process (AHP), which is by its very nature a multi-criteria approach, is another way to consider. Saaty (1988) was the one who first to introduce the AHP model. Partovi and Burton (1993) were the first to suggest using the AHP as a tool to categorise and prioritise maintenance tasks. Gajpal and Ganesh (1994) investigated how to use the approach for categorising spare parts by suggesting an application of AHP with VED in order to categorise spare components. After many decades of use in scientific research, AHP has established itself as a versatile instrument that can be used to combine qualitative and quantitative features while also allowing for the assignment of weights to various criteria when their value is not the same.

An additional AHP application for spare parts classification was offered by Sharaf and Helmy (2001), while Cakir and Canbolat (2008) referred to it as a valuable tool when paired with fuzzy logic for multi-criteria inventory classification in a paper published in 2008. The latter suggested fuzzy logic as a technique for capturing the uncertainty associated with criterion assessments, and this was accepted by the community. By using fuzzy optimization, they are able to prioritise without having to develop comparison matrices. Instead, they are able to deduce the priority values straight from the judgement set, which saves time and effort. The algorithm proposed by Zeng et al. (2012) is a hybrid of AHP, fuzzy comprehensive evaluation, and grey relational analysis. It is used to convert qualitative descriptions of spare parts into quantitative data, which is then used to confirm the criticality classes of the spare parts in a highly uncertain environment with limited data. AHP is also a critical tool in the Braglia et al. (2004) model, which relies on it heavily. According to his research, a multi attribute spare part tree analysis (MASTA) for spare parts management is proposed in order to determine the most effective techniques for spare inventory categorization. This is the first article to clearly link the categorization of spare parts with the choice regarding which management practises should be followed for specific types of spares, and to do so from an integrated standpoint. According to Danas et al. (2006), the MASTA approach was applied to the healthcare business and was shown to be effective.

For the goal of considering both quantitative and qualitative criteria for spare part management analysis, the present study is primarily concerned with the development of techniques for multi-perspective categorization. With a multi-criteria perspective, it is clear that the identification of the relative importance of criteria is a common issue in spare parts classification: a part classification method should include an algorithm, model, method, or approach for determining the relative weights/importance of the criteria. The proposals from literature to this end are frequently either too complicated in practise (as is the case when fuzzy logic is used) or too limited in terms of computational effort (as is the case when a linear optimization model is used): these limitations must be taken into consideration when implementing the part classification in the manufacturing industry.

In summary, the theoretical analysis indicated the importance of adopting the multi-perspective aspect of classifying and managing spare sparts. This study would adopt the use of the Arena Simulation model to simulate the spare parts management of XYZ company.

2.2 Empirical Review

2.2.1 Inventory management

In the literature, the term "inventory" is defined in a number of different ways. In general, inventories are the stockpiles of raw materials, packaging materials, work in progress, and completed items that emerge at various points across a company's production and logistic channel (Ballou, 2005). For example, Pycraft et al. (2010) defined inventory as the stored accumulation of material resources in a transformation system, whereas Chase et al. (2006) defined inventory as any object or resource that is utilised by an organisation.

Essentially, inventory management can be defined as a set of policies, procedures, and controls that are used to systematically monitor and observe inventory levels and intelligently determine at what levels the inventory should be maintained, when the inventory should be replenished, and how large a quantity of inventory should be ordered to meet the needs of the organization's operations. Inventory management is a continuous process of planning, organising, and regulating inventory with the goal of minimising the investment in inventory while also maintaining a healthy balance between supply and demand (West, 2009).

In a statement of financial position, three basic categories of inventory are presented: completed items, raw materials, and work in progress (or work in progress). Finished products are items that have been made by a firm and have been finished and are ready for sale. They are consumable commodities that are sold by the company to wholesalers, retailers, and prospective consumers, among other places. In the context of manufacturing, raw materials are commodities obtained by purchase, extraction of natural resources, or growth for the purpose of being processed into completed products (Saaty, 2008). Once they have been processed, they are transferred to work in progress and finally to finished items. Take, for example, the production of lubricant formulae by a producer of lubrication goods. Base oil and additives are combined to generate lubricant formulas. Work in progress refers to products that are in the process of being made but have not yet been completed as finished goods at the end of the accounting period in which they were purchased. It is carried forward to the following accounting period to make up for the unfinished output. Work in progress is valued at the sum of the costs of labour, materials, and overhead incurred up to that point in the process (Roda et al., 2012).

Cheung et al. (2004) indicated that the profitability of a corporate entity is strongly dependent on the success of inventory management, which includes the reduction of stock-handling costs and the correct streamlining of the manufacturing process. This is reinforced by the findings of Shin et al. (2015), who discovered that US manufacturing businesses with lower inventory-to-sales ratios had greater profit margins. As a result of enhanced inventory efficiency, small businesses stand to gain more than bigger businesses. The findings of the authors support the findings of Mittal et al. (2014), who discovered that fertiliser firms in India had a longer average inventory conversion duration, which suggests slower stock movement, as well as lower profitability numbers than other countries. This research shown that excellent inventory management does really promote the achievement of favourable outcomes by a corporation. For example, Talavera et al. (2015) discovered that the average time spent manually searching for a completed product was 15.5 minutes, which is a substantial amount of time.

Although search times may be lowered by utilising better inventory management control devices such as radio-frequency identification (RFID) technology, labour expenses can be saved by employing better inventory management control devices. Inventory management may be made more efficient in a variety of ways. As suggested by Williams and Tokar (2008), some of the popular methods and techniques that have attracted a great deal of empirical research and findings include implementing a periodic review system (Ballou, 2005; Blumenfeld et al., 1985; Hsu and El-Najdawi, 1991; Sezen, 2006), using technology such as RFID (Fan et al., 2015; Talavera et al., 2015), centralization of stocking locations (Evers, 1999; Waller et al., 2006; Mason et al., 2003; Thomas and Tyworth, 2006). Also important in enhancing inventory management effectiveness are other aspects such as staff training, a good management attitude toward the task at hand, supplier empowerment, active customer relations, and buying (Pillai, 2014).

2.2.2 Inventory costs

A number of factors must be taken into consideration when evaluating the optimal inventory levels in inventory management. According to Owoeye et al. (2014), the cost of acquiring and maintaining inventory may account for as much as 60 to 80 percent of the entire cost of a product or service. The holding, ordering, and stockout costs, according to Gourdin (2005), are the three categories of expenses that must be taken into consideration.

2.2.3 Holding or carrying cost

Storage, insurance, taxes, obsolescence, theft, and interest on cash or borrowing used to finance the products are all included in the holding expenses. These expenses grow in tandem with the increase in inventory. In order to keep the carrying cost as low as possible, management often places frequent orders for modest amounts. When assessing holding costs, it is typical to use percentages of a unit rather than trying to represent the cost as a monetary value for each expense separately. This technique reflects the difficulties in quantifying a particular per unit cost, such as obsolescence cost, because of the inherent difficulty in measuring a precise per unit cost (Ploskas et al., 2014).

2.2.4 Ordering cost

Ordering costs are the expenses incurred as a result of placing an order. Costs associated with labour and staff in a purchase or procurement department, communication costs (including phone, mail, and internet), and any money spent to manage the associated paperwork are included in this category. It might be possible to lower these expenses by placing a modest number of orders in huge quantities. Ordering costs, in contrast to holding costs, are often stated as a monetary value per order placed.

2.2.5 Stockout cost

In addition to revenues that are lost in the immediate and long term as a result of the company's failure to fulfil the customer's request, stockout expenses also include inventory replacement costs. The client may decide to move to one of the rivals' goods, either temporarily or permanently, resulting in a significant loss of income for the company. This cost is likely the most difficult to calculate, but it is also the most essential since it reflects the cost borne by customers (internal or external) when inventory regulations are not followed properly. When management fails to recognise and account for these expenses, it may be forced to maintain greater or lower inventory levels than what is necessary to meet consumer demands. The authors (Ali and Asif, 2012) contend that an efficient inventory management system may minimise the risk of having insufficient inventory, hence lowering the cost of lost consumers. Additionally, it indirectly reduces the likelihood of client dissatisfaction with the product.

Perspective of Spare Parts Inventory Management Characteristics

The examined literature is grouped in this paragraph based on the features of spare parts inventory management, which include inventory policy, the number of inventory units, and the source of spare parts inventory supplies, among other things (Brahimi and Khan, 2013).

2.2.5.1 Inventory Policy

In order to manage the spare parts inventory of a product during its lifecycle, certain rules are put in place. Policies for continuous review and periodic review are generally used in the beginning and maturity stages, while policies for final order are often used in the end-of-life (EOL) phase.

2.2.5.2 Continuous review policy

A programme of continual evaluation ensures that the amount of spare parts inventory is always evaluated and updated as needed. It is possible to distinguish between two forms of continuous review policies: the (s,S)policy and the (q,r)policy. When the inventory level goes below the reorder point, a new order is issued to bring the level back up to the order-up-to level(S)in accordance with the policy (s) (Diallo et al., 2008), The ordered amount is equal to the difference between the Sand inventory level at the time of ordering and the Sand inventory level at the time of ordering. It is a particular instance of (s,S)and is frequently used for repairable spare parts since the one-for-one replenishment mode may imitate the repair process (Diallo et al., 2008). The one-for-one replenishment policy or base stock policy is a special case of (s,S)and is extensively used for repairable spare parts. For example, when a product is being repaired, resulting in a one-unit demand for a repairable spare component, a new spare part is utilised to replace the defective one, which is then sent out for repair and will be returned to inventory as one unit when the repair is completed. While the (s,S)policy has an undetermined order size, the (q,r)policy has a set order size (q), and the order is placed when inventory levels are no greater than the reorder point, both policies have the same order size (q) (r) (Diallo et al., 2008).

2.2.5.3 Periodic review policy

Under a periodic review policy, the spare parts inventory level is monitored in acyclic or periodic manner. The most widely used periodic review policy is(R,S)policy, in which orders are placed at the start of every fixed ordering cycle(R)to ensure that the inventory level reaches the order-up-to level(S). The length of ordering cycle is usually predetermined by decision makers (Durán, 2015). It is notable that the implementation of continuous review or periodic review policy is mainly decided by the decision makers based on how the spare parts inventory is managed. In addition, it is possible to adopt both inventory policies in an particular inventory network. For example, in some studies, different inventory policies are used in different echelons of a multi-echelon inventory network (Durán, 2015).

2.2.5.4 Final order policy
A last order is issued to supply demand for spare parts at the end-of-life (EOL) phase when the manufacture of spare parts is ceased. End-of-life inventory issue, end-of-production problem (EOP), or final purchase dilemma are all terms used to describe this situation in the literature (FBP). The inventory owner would be exposed to significant obsolescence and disposal concerns, as well as a high inventory holding cost at the end-of-life phase if an excessive number of spare parts were bought (Jin and Liao, 2009). The converse is true: if the final ordered quantity was insufficient to meet the demand for spare parts during the final period, the OEM or maintenance provider would be unable to fulfil the service contracts or warranty obligations, and would be subject to financial penalties, customer dissatisfaction, and brand image damage (Jin and Liao, 2009).

2.2.5.5 Maintenance strategies
When products are maintained or components are changed, maintenance methods are used to identify the best time to do so. These techniques are categorised as either preventative maintenance or corrective maintenance. It is the goal of preventive maintenance to maintain products or replace components before they fail in order to avoid product failures. Preventive maintenance is only effective if the product status is known with confidence/ Preventive maintenance is scheduled in each planning period and results in an increase in the demand for spare parts that is anticipated. Preventive maintenance, on the other hand, cannot eliminate component failures since parts may fail before they are replaced or maintained (Sarker & Haque, 2000). Furthermore, certain kinds of spare parts, such as electronic components, do not wear out, which means that the states of the components cannot be utilised to determine the maintenance plan for such components. Corrective maintenance procedures are used in these situations when component failures occur, resulting in an unexpected increase in the need for spare parts (Sarker and Haque, 2000).

3.0 Methodology
According to Banks et al. (2002) supply chain simulation is unique and different from other applications of simulation. Supply chain simulations incorporate discrete event simulation in order to analyze and solve problems relevant to the management of supply chain.

The study was carried out with data collected from XYZ company. The XYZ company is a telecommunication service provider providing maintenance services to OEM companies operating in Ghana. Data on the demand for spare parts from the passive department of the company as well as the inventory and restock levels of spare parts were obtained from the procurement department of company XYZ.

3.1 Data Analysis
The data was first inputted into the Arena Simulation input analyzer. The purpose of the input analyzer is to fit distributions to a given sample. The input analyzer was used to select the best fit by selecting the fit all function.

3.2 Data processing
Arena employs an object-oriented design for entirely graphical model development. The data was simulated by placing graphical objects which are referred to as modules in a layout in order to systematically define the processes involved in the demand for spare parts at XYZ company. At the end of creating the simulation model, the model was run through the process analyzer to ensure all the processes are well defined. The model was run for specified time period and the results interpreted (Altiok and Melamed, 2010). A good design of simulation replications allowed the researcher to obtain the most statistical information from simulation runs for least computational cost. It is important to minimize the number of replications and their length in order to obtain a reliable statistic. In order to decide the number of replications, the model must run some initial set of replications so that the sample average, standard deviation and the confidence intervals are computed.

4.0 Presentation of results
4.1 Data Collection and Input Analyzer

4.1.1 Demand Input Analyzer
From the result of the input analyzer on demand from the passive department to the procurement office of XYZ Company, the best fit distribution of demand is lognormal distribution of 0.5+LOGN(0,0) with square error of 0.088020 and a corresponding p-value <0.005 hence concluded that the best fit distribution is 0.5+LOGN(0,0). This is represented in figure 4.1

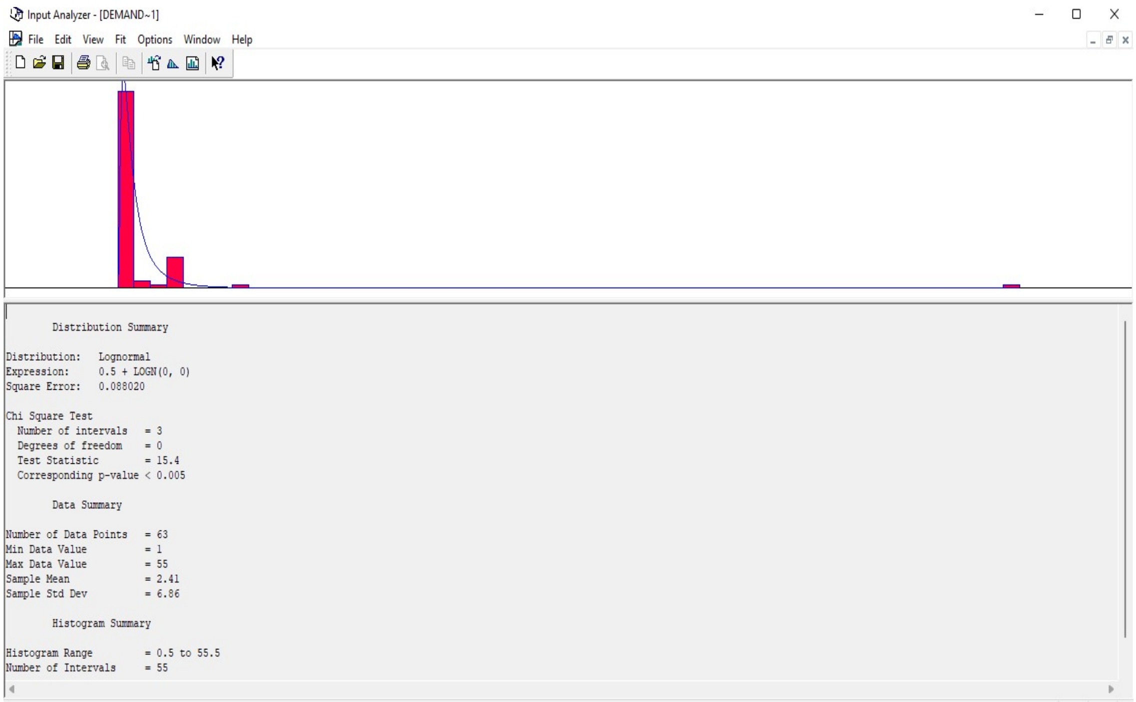

Figure 4.1: Input Analyzer-Demand

Furthermore, figure 4.2 shows the result of the input analyzer inventory levels in company XYZ. The result indicated that the best fit distribution of the demand size is Weibull of -0.001+WEIB (0,0) with square error of 0.00482 and a corresponding p-value <0.05.

Figure 4.2: Input Analyzer-Inventory

The figure 4.3 below represent the process of spare parts inventory management at company XYZ where the process of managing spare parts by the procurement department is presented.

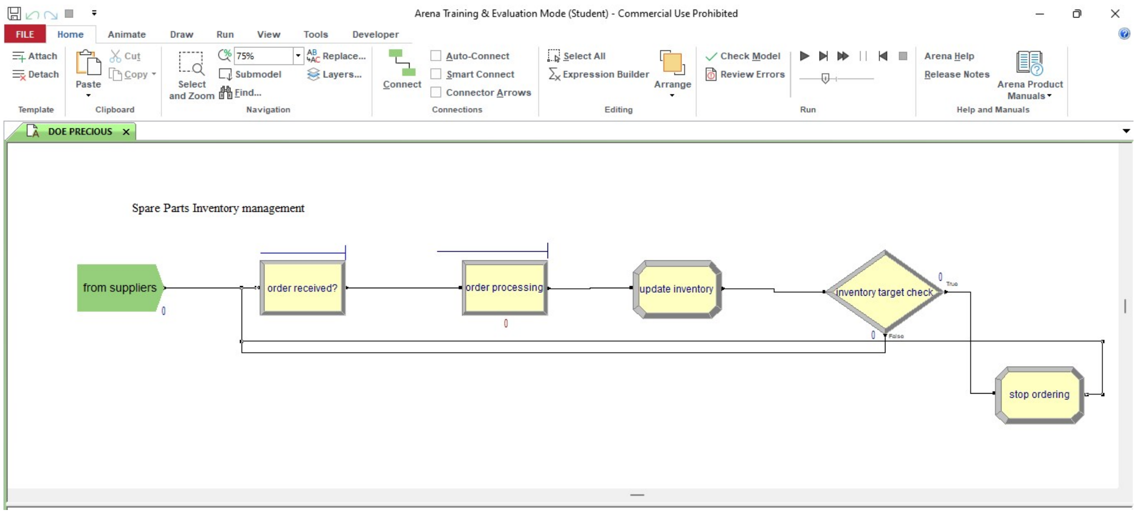

Figure 4.3: Spare Parts Inventory Management

The figure 4.4 represent the build up of demand management at company XYZ as represented in the Arena Simulation model.

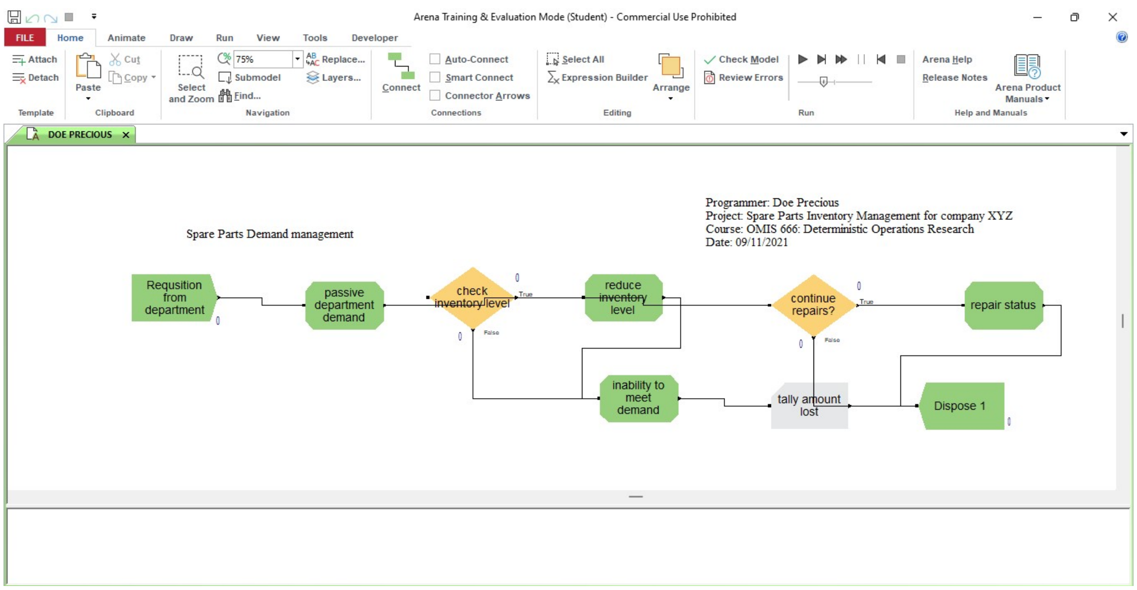

Figure 4.4: Spare parts demand management

The model was run for 30 days with 1000 replications. As indicated in table 4.1 below, the results indicated that on average, 6.08 orders are received from the passive department on daily basis and the maximum order in a day is 13 and the minimum order per day is 0, the results further indicated that in a normal day, 0 order is processed by the procurement department indicating that the procurement department is unable to meet the demand from the passive department. Furthermore, average lost per site in terms of long MTTR due to inability to process order in time is 0.66.

Table 4.1: Arena Simulation output

spare parts inventory

Replications: 1,000 Time Units: Days

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	< 0.00	0.00	0.00	0.00	0.00

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	< 0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	< 0.00	0.00	0.00	0.00	0.00

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	< 0.00	0.00	0.00	0.00	0.00

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	< 0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	< 0.00	0.00	0.00	0.00	0.00

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	9.8540	0.19	0.00	13.0000

Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	0.6670	0.03	0.00	1.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	6.7885	< 0.18	0.00	13.0000	1.0000	14.0000

‘

Values Across All Replications

spare parts inventory

Replications: 1,000 Time Units: Days

Queue

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
order processing.Queue	0.00	< 0.00	0.00	0.00	0.00	0.00
order received?.Queue	6.7885	< 0.18	0.00	13.0000	1.0000	13.0000

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
replacement	0.00	< 0.00	0.00	0.00	0.00	0.00

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
replacement	0.00	< 0.00	0.00	0.00	0.00	0.00

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
replacement	0.9950	< 0.00	0.00	1.0000	1.0000	1.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
replacement	0.00	0.00	0.00	0.00

Total Number Seized			Minimum	Maximum

	Average	Half Width	m Average	m Average
replacement	0.00	0.00	0.00	0.00

Values Across All Replications

spare parts inventory

Replications:	1,000	Time Units:	Days

User Specified

Counter

Count	Average	Half Width	Minimum Average	Maximum Average
tally amount lost	0.6670	< 0.03	0.00	1.0000

Time Persistent

Variable	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
level of inventory	248.75	< 1.09	0.00	250.00	250.00	250.00
type of repairs	0.00	< 0.00	0.00	0.00	0.00	0.00

5.0 Conclusions and Recommendations

The management of spare parts in service operations is very important especially for companies that operate on Service Level Agreements where they are to manage the MTTR in order to avoid long down time. The study adopted the use of the Arena Simulation model to analyze data collected from the XYZ company. The results of the analysis indicated that the procurement department is unable to meet the spare parts demand of the Passive department where the average order received from the department in a day is 6.08. Based on the findings of the study, it is recommended that the procurement department put in measure to receive and process orders in time. The reason for the delay in processing orders could be the less poor inventory management practices of the company. The study recommends that systems be adopted to track the inventory level of the company. Due to the stochastic nature of the demand from the passive department, the company should be proactive in the management of the demand by keeping the right stock level in order to meet the demand of the department in order to reduce the long down time.

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