# *Requirements Engineering for Inventory Management of Locomotive's Electronic Modules Maintenance*

Thomas O. Magae
Faculty of Engineering and Built Environment
University of Johannesburg
Johannesburg, South Africa
otsile.magae@gmail.com

***Abstract* – Inventory Management is an important discipline that identifies tracking of software and hardware assets for manufacturing, maintenance, or retail purposes. Inventory management systems and processes can use similar terms as in literature but the environment where the asset's inventory is used determines the requirements for that asset. Availability of locomotives for operations is key in supporting the economy of the country; therefore, locomotive availability should always be high. The current inventory management process is not fully utilized to support the locomotive maintenance business efficiency. Most failures in locomotives are due to electronic modules so it is important to efficiently manage the electronic inventory items for locomotive maintenance. The requirements for inventory management system needs to be elicited from the experts in the locomotive maintenance business. The stakeholders are engaged using the interview method to get the ideal requirements per their expertise. The Delphi method is adopted to validate a set of gathered requirements and the Likert scale of 1 to 5 points is used to draw consensus from the participating experts through a statistical group response. The research data shows a set of gathered requirements elicited from the stakeholders. The requirements are validated and the recommendations made based on the findings. It can be drawn from the results of using the Likert scale that the inventory management system would work better if enhanced by automated sub-systems such as barcode systems and point-of-sale machines. This paper is the first that provides additional requirements from a population of stakeholders and recommends that further research is made to find out about the impact of using latest technologies to enhance inventory management of electronic modules for locomotive maintenance.**

***Keywords* – *Elicitation, Inventory management, Maintenance engineering, Requirements engineering, Stakeholder.***

## I. INTRODUCTION

Transnet is a South African state-owned company that operates the largest freight logistics chain in Southern Africa. Locomotives are used across the country to transport different commodities to ports at sea and to different companies inland. Improving performance, productivity and operational efficiency calls for speed in locomotive maintenance. Repair of electronic modules in a locomotive maintenance business uses inventory that ranges from small electronic components to assembled electronic modules. The repair inventory needs to be available and accessible at the instant when they are required. Some business managers overstock the inventory to make sure that it is available whenever it is needed. The overstocked inventory may not be the required inventory and the required inventory is sometimes understocked. The use of some inventory as a buffer helps hedging against uncertainty but the most important factor for the business today is the cost of capital **[1]**. A research is conducted to determine high level inventory system requirements, validate requirements research data, and recommend an inventory management system conceptual design.

In the current inventory system, some of the tasks are manually executed and this results in the inconsistence of the logged data due to human error. The repair inventory is either in excesses or there is a shortage, leaving the business with the inability to properly draw a financial budget.

This research paper answers the question "What are the engineering requirements for an inventory management system of electronic modules or components in a locomotive maintenance business?" using a set of questionnaires to elicit the requirements from participating stakeholders. The objectives of this research are: To identify from literature the requirements for inventory management in electronic device repair shops; To identify the current inventory management processes in Transnet; To see how other companies manage their inventory; To identify stakeholder requirements and propose a design for an inventory management system. The purpose of this paper is not to design but to come up with recommendations for the design of the system guided by the elicited stakeholder requirements.

## II. LITERATURE STUDY

Inventory management provides service records of all items in the inventory and financial records specific to an item or a group of items **[2]**. The functional areas of the system

may be made up of the user who makes requests, control management who makes sure policies and guidelines are adhered to, financial management where all finance records are kept for future or current use, reporting, and hardware and software subsystems.

The inventory management strategies of medium sized flour milling companies in Lagos, Nigeria are based on changing level of customer demand, prevailing industry practices, forecasting estimates and available production capacity. They did not use the scientific models and as a result a research was done and found that there was a need to implement a scientific model for inventory management to deal with material shortage, product stock outs, and components pile up with consequent penalties. They used a cross sectional survey design because it allows for rapid data collection and has the ability to understand the characteristic of the studied population **[3].**

Many industries have adopted automation to fast track production and improve product quality. Manual Inventory processes are time consuming because the user manually updates records and the manager must verify them at the end of the day. The supermarket inventory management was studied where an Android application was used to update the user of stock availability. This meant that whenever the product is purchased then it automatically updates in the database that there is reduction in stock. The aim of the study is to design a computerized inventory management system that will establish stock taking levels, update transactions and help in stock taking **[4]**. The Android application was developed to automatically alert the supervisor of the required inventory by means of notification.

One of the systems that can enhance automation of the Inventory Management System (IMS) is the use of Point-Of-Sale (POS) system. POS system captures customer transaction in real time and customer history and preferences can be viewed at later stage whenever required. The POS also accepts multiple payment options, ring up individual sale items via camera based barcode reader, allow users to return items and keep inventory levels updated as orders are processed. A study was conducted to design an inventory management system, using a POS with an Accounting system, Payment system, Inventory procurement, Inventory management and a backup server. The IMS allows the merchant to perform stock taking, set low inventory alerts, analyze historical data, editing of inventory and manage mark-ups. The accounting system allows importing of sale information from POS system and assets information from IMS. From this information, accounting reports will be generated then the user can save these reports and distribute them via email **[5]**. The Aberdeen Group analyzed the benefits gained when using a computerized POS system and IMS as compared to the benefits of using the traditional Electronic Cash Register (ECR). With the help of the computerized POS system, they found that they were able to log information such as what is selling, how much is selling, when to buy additional merchandise, and who is the most likely customer for that merchandise. This information was beneficial to the business as it improves customer care and item on time delivery as per customer agreements **[6]**.

After computerization and automation, there is another factor to deal with and that is uncertainty. There can be uncertainty from market behavior or operational environment. Rui Fernandes, Borges Gouveia and Carlos Pinho found that the need to consider uncertainty can be traced back to core functionality of planning models, which refers to the future allocation of resources based on the current information and on future projections. They adopted the distribution based approach as a methodology to represent uncertainty as there is no need to forecast all possible outcomes **[7]**.

Forecasting is subject to errors but the knowledge of errors enables the definition of the necessary safety stocks. Different models have been developed for forecasting. These models include Periodic review, Continuous review, and Base stock model. Poisson distribution as an alternative to traditional methods that use classical exponential smoothing time series forecasting was used in a study **[8].** The following assumptions were used for the best inventory sizing method:

- Defects due to the infant mortality were eliminated in the burn-in process;
- The components follow an exponential failures law;
- There is no degradation of parts during the storage period (bottom of the “bath-tub” curve);
- Only the items damaged in the equipment are replaced by spare parts during the repair;
- The failure rate is considered constant over the period forecasted for the stock, and the failures are resulting from stochastic and independent events, by intrinsic mechanisms of the own item;
- The equipment is operating according to normal specification conditions, receiving all;
- The recommended preventive maintenance, as well as all the corrective maintenance needed to restore it to original specification conditions and level of quality; and
- The spare quantities of the item necessary for repairing failures, other than those resulting from the processes listed above, are supplied by additional stocks.

The alternative method provided a significant reduction of poor forecasts.

Inventory management can be improved by adopting the fourth industrial revolution framework. This includes, digitization of product and service offering, digitization of vertical and horizontal value chain, and digitization of business models and customer access. This means the existing products can be expanded by integrating sensors

and data analytics tool, optimization of customer interaction and access, and integration of external and internal operation of the organization to improve operations planning, quality management and process efficiency **[9]**.

The ultimate goal of a maintenance business on its inventory is to achieve zero inventories to save the company's space and reduce material loss due to accumulating for long, and going digital is the way to achieving this goal. A paper was presented in a conference of Advanced Mechanical Engineering and Industrial Informatics (AMEII) in 2015 for research and design with a topic "The Materials Inventory Management System Based on Digital Pipeline". The key technology of the system is developed using Visual Studio 2012, SQL 2008 for backend database, C# as a programming language, and adopts B/S (Browser/Server) architecture and Microsoft Silverlight technology. Users can export the report to Adobe PDF, MS Office, and other software. The export format can be Word, Excel, PDF or other formats **[10]**.

The two main challenges facing the rail industry are the need to improve frequency and to maximize operational effectiveness. It is good for an organization to operate an efficient business with minimum operating costs. Olsson and Corbett conducted a case study and identified a solution for optimization of the rail fleet spare parts inventory. They used the Syncron Global Inventory Management system because of its excellent functionality and the System Application Products (SAP) certification that will provide seamless interaction with their SAP system. The system adopts forecasting methods and algorithms, based on each part's demand information. As the fleet grows so does the number of repairs and maintenance events. This is handled automatically by the demand trend classification on the Syncron system. The system optimizes the repairable parts process across the different depots of the Maintenance, Repair and Operation (MRO) supply chain by automatically forecasting and scheduling the repair of parts in the exchangeable repaired items pool. Repair and supplier orders are created based on aggregated demand streams for parts of the warehouse and replenishment parameters including both repair and supplier lead times. The Syncron's Global Inventory Management system provides greater efficiency in forecasting, replenishment, and distribution processes to ensure the highest service level and train uptime **[11]**.

Similarly, to the rail industry, in the aviation industry high availability of aircraft is crucial for any airline operator. A study conducted on spare parts inventory control for an aircraft component repair shop, reveals how data is obtained and used to implement automated inventory management system that aligns inventory decisions with performance targets. The approach proposed, addresses the following properties in a repair shop ordering problem:

- Inventory decisions are taken for spare parts that are made-up of components, while performance is measured on components level repair;
- The shop repairs hundreds of components and stocks thousands of spare parts;
- Spare parts are slow moving and demand during lead time is discrete; and
- Parts are ordered in batches because many parts are relatively inexpensive and ordering involves fixed cost.

The algorithm for optimizing (s, S) policies scales to system of thousands of spare parts and components **[12].** In these policies, the small letter s represents the lower bound for ordering to keep the stock at the desired S. The study concluded that it is better to perform inventory management on component level rather than on spare parts level.

Without proper control, inventory tends to grow beyond economic limits and increase the cost of maintenance. Selective control technique is aimed at investing efforts where results are worth it, and selective control techniques are chosen based on a situation and nature of inventories. There are eight (8) different types of selective control techniques amongst others, namely **[13]**:

- ABC – Always Better Control;
- HML – High, Medium, Low;
- VED – Vital, Essential, Desirable;
- SDE – Scarce, Difficult, and Easy to obtain;
- GOLF – Government, Open market, Local and Foreign source;
- FSN – Fast moving, Slow moving, Non-moving;
- SOS – Seasonal and Off Seasonal; and
- XYZ – Is based on the value of the inventory stored.

The other inventory selective control technique is the MRP (Material Requirement Planning) which in mainly used for managing manufacturing processes. The objectives of this planning techniques are to, ensure material is available for production and complete products are available for sale to customers, and to help organization maintain low inventory levels. MRP also provide answers to questions like;

1. What items are required?
2. How many items are required?
3. When are they required?

VED is based on the criticality of the inventories while the ABC technique is based on consumption value **[14]**. Further, ABC is used to identify items that need more attention for control. According to this tool, category-A means 10% of the items consume 70% of the budget, category-B refers to 20% of the items that consume about 20% of the budget and the remaining category-C is for the remaining 70% items that consume only 10% of the budget.

The limitation of the ABC is that it is based on the monetary value and the cost of item consumption of the items. To complement this limitation, ABC analysis is used with the VED analysis. The V is for vital components that the business cannot operate without and the E is for essential items that the business can operate without but quality may be compromised and lastly D is for desirable items that the business can operate without them **[15]**. The unit price of the items is multiplied by the consumption per period and the items are categorized A, B or C. For VED, guidance is given by the experienced business stakeholders.

Each component of inventory is important and managing the inventories to keep in an optimum level is a must **[16]**. A research was conducted at Amara Raja Electronics Ltd with the following objectives:

- To know the inventory turnover ratio;
- To know the financial performance on Inventory at the organization;
- To calculate Economic Order Quantity (EOQ) for each raw material at the organization; and
- To study the effective utilisation of the inventory by using ABC analysis.

In the methodology they collected data from annual reports, schedules, stores ledgers, budgets and purchase orders. They concluded and recommended that if a company were to strictly follow management techniques like EOQ and ABC analysis, their profits would increase.

A case study in the manufacturing of Electrical Multiple Units (EMU) coaches using FSN analysis was conducted based on turnover ratio. The turnover ratio is calculated using annual demand over average inventory consumption. This analysis helps to determine the items that are Fast (F) moving, items that are Slow (S) moving and items that are Non (N) moving. The case study found that priorities of the items changes according to different inventory analysis technique; the management of the company decides which process to follow taking into account their budget, supply, demand, and their inventory carrying capacity **[17].**

It is always easier to group items with similar patterns of consumption and choose an applicable strategy for each group; but there is a need to understand if there are limitations and underlying issues before any of the strategies are employed. Using XYZ come with a number of challenges relating to computations of statistical parameters such as standard deviation (SD), coefficient of variance (CV) and mean values. There are some challenges in using the XYZ analysis technique. In this technique X refers to uniform demand, Y refers to varying demand and Z refers to abnormal demand **[18]**. This technique is mostly used where the demand of items can vary dramatically every month and if employed can have some uncertainties depending on the period used for analysis. Additionally, there are other drawbacks with this analysis. One drawback is that categorization of new products is classified as Z because their demand has not yet been established. The other drawback is that XYZ analysis may exclude seasonal items and this can be challenge if this items costing is significant on the budget.

The SDE analysis looks at Scarce, Difficult, and Easily available items. Scarce items are those that are in short supply and have the longest lead times, these items are usually the imported raw material or spare parts. Difficult items are those that are not available in local markets or items for which there is less number of suppliers in the industry of operation, these items usually have somewhat short lead times. Then we have easily available items with the shortest lead times compared to those in category S and category D **[19].**

This paper borrows from literature and shows the methods used to collect and analyze data and show the research results for the requirements data gathered for the inventory management in the locomotive maintenance environment.

## III. METHODOLOGY AND RESEARCH DESIGN

Research design can be defined as a plan for selection of subjects, research locations, and data collection procedures to answer a set of research questions **[20]**. Decisions with regards to questions of what, where, when, how much, by what means concerning a research constitute a research design **[21].** This research intends to identify a set of engineering requirements necessary for an economically reasonable IMS design of Locomotive's maintenance shops at Transnet. The research methodology elaborates on the development of research questionnaire, the gathering of data and its analysis, together with the identification and engagement of stakeholders.

The research data presented in this paper was collected using the interview method. Compared to the computer aided survey method, the interview method was found to be effective when looking at the participants and the people's culture where the locomotives operates. The advantage of face-to-face interviews is that questions can be elaborated on and more questions can be asked to get clarity.

Requirements Engineering process was used to gather the data and combined at the end with the Delphi method to validate the requirements data using the 5-point Likert scale to reach consensus among stakeholders and system experts.

As it appears in Figure 1, elicitation is the first phase where requirements are collected and then they are analyzed before they can be converted into specification. The final phase comes after modelling and some initial developments where verification

Faculty of Engineering and Built Environment, University of Johannesburg

takes place to validate the initially set requirements from all stakeholders.

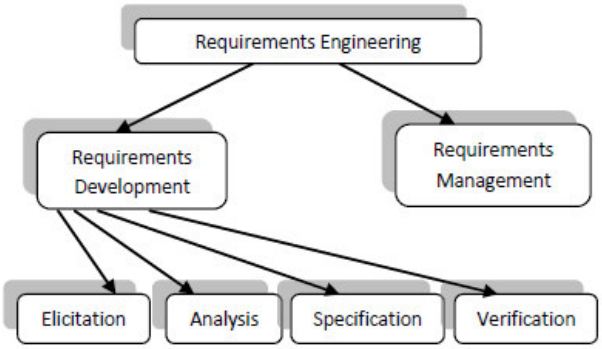


**Figure 1: Requirements Engineering framework [21].**

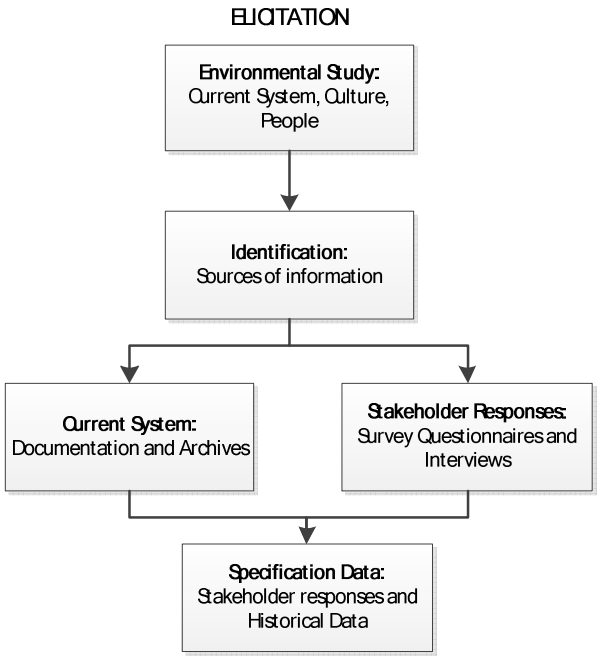


**Figure 2: Requirements elicitation process.**

Data is collected, categorized and taken through the Delphi process for validation and consensus among the system experts and stakeholders using the 5-point Likert scale.


**Figure 3: 5-point Likert scale [22].**

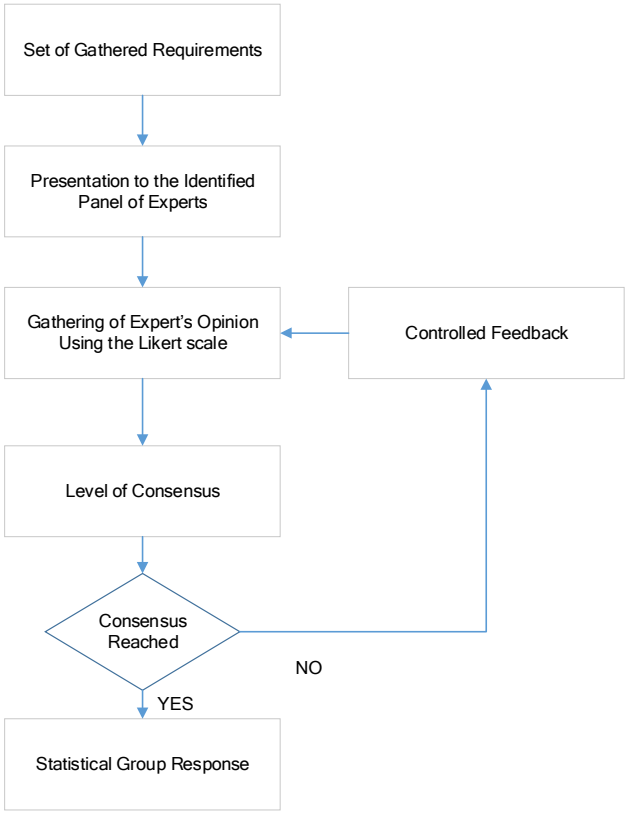


**Figure 4: Delphi method used to validate research results[22].**

For this paper, research results are validated by the review panel and the stakeholders. With the availability of different approaches to address validity, the triangulation of information from different sources of data is adopted and stakeholder feedback is used to validate and verify research data.

## IV. RESEARCH RESULTS

There were 14 participants who took part in various interviews from different places. The interview's audio is transcribed manually because different languages other than English were used by participants for one session interview.

**Table 1: Interview attendees and their designation.**

| Umbilo Depot | |
|---|---|
| **Designation** | **Number of Attendees** |
| Logistics Manager | 1 |
| **Sentrarand Depot** | |
| **Designation** | **Number of Attendees** |
| Logistics Manager | 1 |
| Planner | 2 |
| | |
| Stock Buyers | 2 |
| Technical Workers | 3 |
| **Bellville Depot** | |
| **Designation** | **Number of Attendees** |
| Logistics Manager | 1 |
| Technical Worker | 1 |
| **Koedoespoort Depot** | |
| **Designation** | **Number of Attendees** |
| Supervisor | 1 |
| Technical Worker | 2 |

The participants were happy with the data captured and are looking forward to seeing a plan of action where they will take part in managing the gathered requirements.

The following requirements were gathered during elicitation of the data and were validated using the Delphi technique. The requirements are extracted from sections in chapter 4. Also, the requirements are rated as essential, conditional, or optional. The following definitions were used to describe the importance indicators.

- Essential – The system's software will not be acceptable unless these requirements are implemented as agreed.
- Conditional – The system may be accepted if the requirements are not implemented.
- Optional – These requirements are the extras that may be beyond the scope of the system development.

FUNCTIONAL REQUIREMENTS

The functional requirements explain what software product is used and how it should operate in accepting and processing user's input, and processing and generating the desired outputs.

**Table 2: Functional Requirements (FR).**

| No. | Requirement Descriptions | Rationale | Importance |
|---|---|---|---|
| FR1 | The software shall request log-in details of the user for every session of usage. | To identify sources of records. | Essential |
| FR2 | The software shall log and link user's details, with the records updates. | To identify sources of records. | Essential |
| FR3 | The software shall give an option to generate user history report of all records per selected period. | This is to score the user for records update accuracy. | Essential |
| FR4 | The software shall be able to analyze each material's profile and log material usage data. | To understand each material consumption and reloading | Essential |
| FR4.1 | The software shall link the approved suppliers to each material item. | To reduce time of ordering material | Essential |
| FR4.2 | Update the lead times for each item and supplier production capacity | Calculate the time it takes to maintain or produce a product. | Conditional |
| FR4.3 | Link approved supplier's material availability data to the company inventory system. | Reduce the time of procurement. | Optional |
| FR5 | The software shall compute and categorize material using the ABC technique. | To know what material is important for the organization. | Essential |
| FR6 | The software shall generate reports for A category items, B category items and C category items. | For management reporting and analysis | Essential |
| FR7 | The software shall automatically send material's reorder-point alerts. | To make sure material is ordered on time | Conditional |
| FR8 | The software shall link reorder points with the Physical and Ad-hoc inventory count. | This to make sure that material is counted when necessary. | Optional |
| FR9 | The software shall send reminders for Physical and Ad-hoc inventory count. | Counting of material should be done as per set frequency in the Inventory count policies. | Optional |
| FR10 | The software shall send inventory alerts for abnormal inventory consumption rates. | This is to make sure that uncertainties are mitigated in time. | Conditional |

| | | | |
|---|---|---|---|
| FR11 | The software shall generate an accounting statement for each material or item in the inventory. | To help approximate material's periodical budgets. | Essential |
| FR12 | The software shall generate an accounting statement for the Class of locomotive where the material is used. | To know maintenance budget consumption per class of locomotive. | Conditional |
| FR13 | The software shall generate overall accounting statements for all material consumption. | To assist in auditing. | Essential |
| FR14 | The software shall not continue operating if the user puts wrong data such as personal credentials or wrong material numbers. | This is to emphasize correct data is captured. | Essential |
| FR15 | The software shall alert the user if it detects wrong data inputs. | To make the user aware of wrong input values. | Essential |
| FR16 | The software shall have an inventory management system dashboard. | So that management may view all items of interest. | Essential |

INTERFACE REQUIREMENTS

Interface requirements refers to all hardware and software that support and enable the functioning of the system. These requirements include user interfaces, communication and software interfaces.

**Table 3: Interface Requirements (IR).**

| No. | Requirement Descriptions | Rationale | Importance |
|---|---|---|---|
| IR1 | The Inventory System shall continue using the SAP ERP software. | Save costs on a new system and new skills development. | Essential |
| IR2 | The inventory management system shall have central server computer linked to other computers at the depot warehouses. | To access information from all other depots and repair shops. | Essential |
| IR3 | The inventory system shall have a barcode label generating system. | To uniquely identify different items. | Conditional |
| IR4 | There shall be a barcode reader for each repair shop and Depot warehouse | For ease of stock updates and error reduction. | Conditional |
| IR5 | The barcode reader shall be linked with the Inventory management central server computer. | To dump data automatically. | Conditional |
| IR6 | The inventory system shall have Point-of-Sale machines | To eliminate the use of paper to record inventory data. | Conditional |
| IR7 | The point of sale machines shall be linked to the central server computer via barcode scanners | For ease of stock updates and error reduction. | Conditional |
| IR8 | The system shall use Wi-fi and ethernet for communication of system modules. | To support speed of communication and simple network. | Conditional |

PERFORMANCE REQUIREMENTS

The performance requirements refer to the ability of the system to execute many functions within a desired period and the maintainability, reliability and availability of the system.

**Table 4: Performance Requirements (PR).**

| No. | Requirement Descriptions | Rationale | Importance |
|---|---|---|---|
| PR1 | The warehouse servers and the repair shop server must share the same information. | To be aware of the overall availability of different inventory. | Essential |
| PR2 | All barcode scanners and Point-of-Sale machines shall be calibrated annually. | To improve accuracy of data logging. | Essential |
| PR3 | The software operation shall be audited annually. | To make sure that the software can be improved for better operation. | Essential |
| PR4 | There shall be data storage backup for all warehouses and repair | To access data during system | Essential |

| | | | |
|---|---|---|---|
| | shops. | failure. | |
| PR5 | All system users shall receive certified training. | To eliminate wrong use of the system. | Essential |

The following pie-chart shows the level of importance on all the elicited requirements. The importance for each set of requirements was agreed upon by the experts on inventory management within the organization.

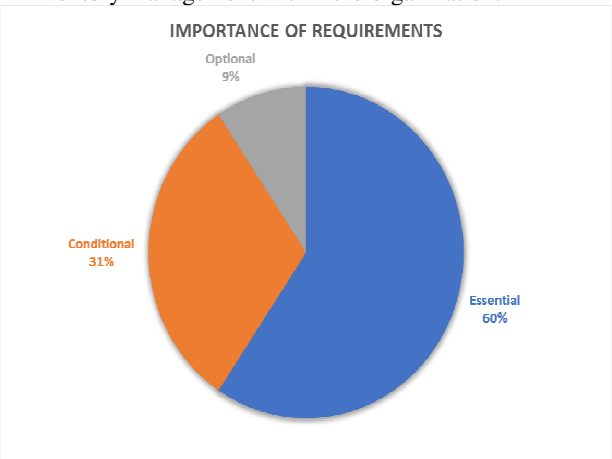


**Figure 5: Pie-Chart for Requirements Importance.**

Following the Delphi process in **Figure 4**, final engagement was made with the experts of the system and inventory management processes using the Likert scales. The five-point scale as shown by Figure 3 was used. The results are plotted in Figure 6, Figure 7, and Figure 8 below.

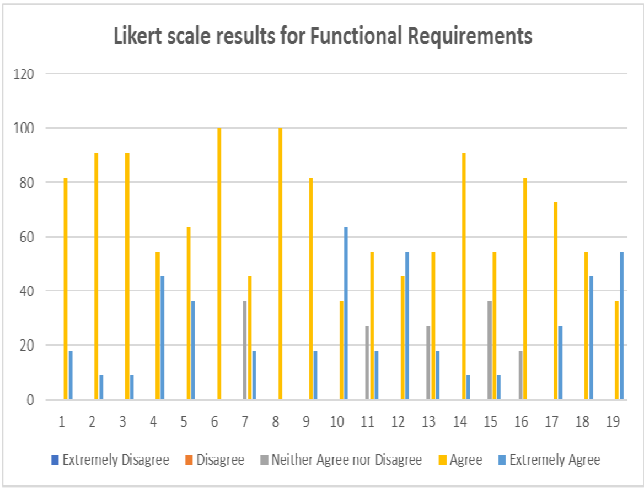


**Figure 6:Functional Requirements with % of Likert scale.**

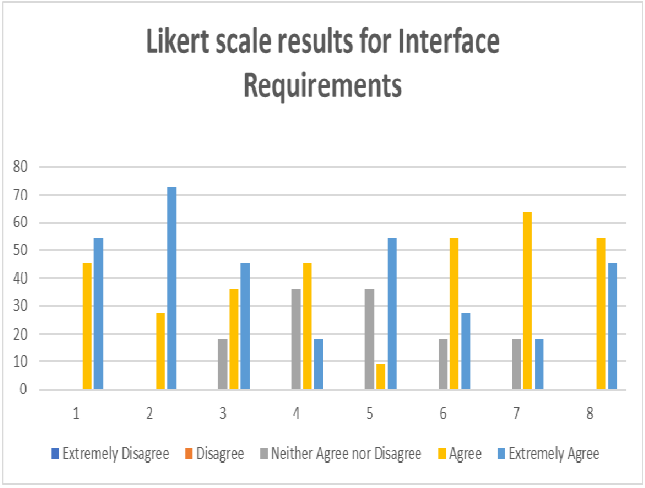


**Figure 7:Interface Requirements with % of Likert scale.**

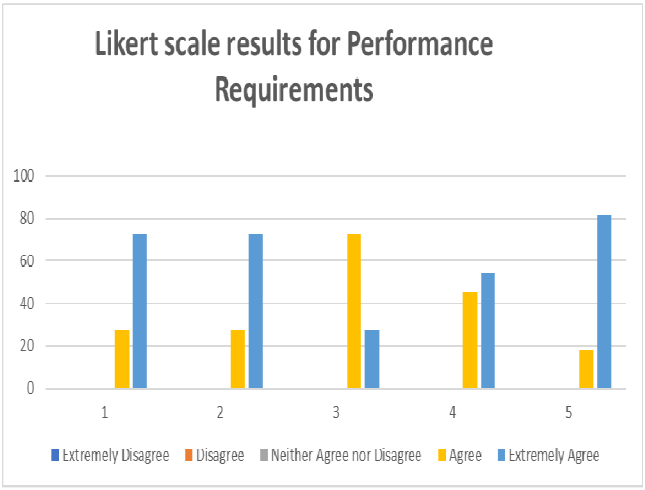


**Figure 8:Performance Requirements with % of Likert scale.**

## V. DISCUSSION

The core objective of these study was to gather engineering requirements for the inventory management system in electronic repair shops of locomotive maintenance business.

The Literature study discussed different methods that are used by electronic businesses to manage inventory. Amara Raja electronics **[16]** conducted research with the objectives of coming up with an inventory management system that can display financial performance for the organization, show the turnover ratio, calculate the Economic Order Quantity, and use the ABC technique in studying the effectiveness of managing inventory. Computerized and automated inventory management are progressive achievements for better inventory management but they cannot deal with uncertainties.

Transnet uses SAP ERP software to assist in inventory management for their maintenance inventory and manufacturing inventory management. There are policies for Ad-hoc inventory counts and for Physical inventory counts that are done periodically to reduce errors in the overall inventory management. They inventory management warehouses adopts the multi-echelon approach and through the SAP ERP software system, the warehouses can do internal sales before approaching external suppliers for emergency stock. The only challenge is that the system is not fully utilized by all stakeholders as effective as per the intended objective.

The last objective was to use the information gathered from literature and engage all stakeholders to gather requirements of the inventory management system for the maintenance of electronic components on locomotives. The inventory management policies apply similarly to all rolling stock equipment but the stakeholders are not the same for all businesses. The locomotive electrical maintenance business has different stakeholders compared to Wheels business, Wagons business, Passenger Coaches and other rolling stock equipment businesses. The stakeholders were engaged through interviews to elicit their preferred requirements for the inventory management system. The requirements were gathered and presented to the stakeholders for verification using the Delphi process. The verification was recorded in Table 2, Table 3, and Table 4. The chart in Figure 5 show the importance of the requirements as agreed upon by the stakeholders.

The five-point Likert scale was used to get the final consensus of the system experts and there results are plotted in Figure 6, Figure 7, and Figure 8. In Figure 6 the stakeholders are more in agreement of the functional requirements since there is high percentage of “Agree” and “Extremely Agree” points. There are about 5 requirements where a small percentage of the stakeholders are not sure whether they agree with the requirement or not. Figure 7 shows the percentage of Likert scale for the interface requirements. Like the results obtained for functional requirements there is also about five requirements that the stakeholders are not sure whether they would agree or not agree to their implementation but there is high percentage where stakeholder either agree or extremely agree with the requirements. The stakeholders are surer about the implementation of the performance requirements as Figure 8 shows that most of the requirements are extremely agreed upon.

It can be deducted that the objectives of these study were met and the recommendations were made with a set of requirements to implement an effective inventory management system for the maintenance of Locomotive’s electronic components.

## VI. Recommendation and Conclusion

What has been clear while conducting this study is that there is an inventory management system that is not used effectively; adding to that, there can be other systems that can be integrated to the current inventory management system to improve its efficiency. The following recommendations are made from the findings of the research exercise.

- Transnet should support further research into inventory management of all rolling stock equipment for maintenance environment. It should be known whether the current system is useful for each business within Transnet’s rolling stock businesses. This study can help to keep check of the overall inventory management of the company in the maintenance environment.
- The should be an investment done towards conducting research on the positive impact that can be brought about by integrating other electronic enhancing systems such as barcode systems, point if sale machines and other mobile devices to the inventory management system. A bankable study such as this one can help in clarifying the possible set of benefits of using latest technologies to enhance inventory requirements of a maintenance business.
- The commissioning of new systems should be done with all stakeholders to improve their usage. All changes should, in time be communicated to all stakeholders. In that way, all stakeholders feel important towards the success of overall company processes and therefore take their role seriously. There should be strategies around how new systems are introduced to all stakeholders and how will the company monitor the usage of the system continuing.
- There should be a strategy developed to change the culture of employees within the maintenance businesses of rolling stock equipment. The culture should be in such a way that employees will learn how to use all systems integrated into the inventory management system and take effort into learning how to use them. This will help Transnet to improve speed of doing business and in achieving the goal of becoming Original Equipment Manufacturer.
- The organisation should consider adopting the Industry 4.0 Framework in its inventory management processes.

If these recommendations are implemented Transnet can better distribute its budget to the inventory management system for maintenance of locomotives. Transnet can also check its inventory management system and see if it is still relevant for industry 4.0 as other companies have improved their system to be of latest technology; and Transnet can be able to compete in the industry of rolling stock maintenance and manufacturing.

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