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Proposal for the automation of the shipping process of automotive parts and improvement the quality management process in the warehouse of Toyota de Venezuela C.A

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Not even long distances can separate us from the important persons in our life.

Abstract

The main objective of this work is to make a proposal to improve the dispatch operation of the TDV's warehouse, having as main concern to reduce errors and costs and to increase quality and service level.

During the analysis it was concluded that the errors done by the operators during the operation are based, in a high percentage, in the comparison of the spare parts' numbers with the picking labels and in the counting of the spare parts. Also it was analyzed that some aspects of the operation, like "credit notes", "picking notes" and picking labels, can be reduced or eliminated.

Using these aspects, there were developed the new processes that will be used during the dispatch's operation. These processes use a barcode scanner as tool to reduce the errors made when reading spare parts' numbers and counting the spare parts. These processes are a picking, a checking and a classification process.

Also, analyzing the warehouse denials it was noticed that there is not a clear reason why these errors are happening. To try to solve this situation it was suggested a system called "data collection system" that will allow to collect the data about the misallocated spare parts with the objective of improve the inventory.

For the application of these processes it was suggested a schedule with a final estimated duration of 53 weeks.

Finally, for all these to be applied, there were suggested quality policies that will help to sustain the changes through time and to facilitate its implementation.

Key words: Quality, barcode, process improvement, automation, warehouse.

Sumário

O objetivo principal deste trabalho é fazer uma proposta para melhorar a operação de envio do armazém da TDV, tendo como principal objectivo reduzir erros e custos, aumentar a qualidade e o nível de serviço.

Durante a análise, concluiu-se que os erros cometidos pelos operadores durante a operação são baseados, em grande percentagem, na comparação dos números das peças de reposição e na contagem das mesmas. Também foi analisado que alguns aspectos da operação, como "notas de crédito", notas de “picking" e etiquetas “picking”, podem ser reduzidos ou eliminados da operação.

Com estes aspectos foram desenvolvidos os novos processos que serão utilizados durante a operação o envio de peças de reposição. Estes processos usam um scanner de código de barras como ferramenta para reduzir os erros feitos durante a leitura de números de peças de reposição e contando-as posteriormente. Esses processos são: um processo de separação, um processo de verificação e um processo de classificação.

Além disso, analisando as “warehouse denials” percebeu-se que não há uma razão clara pela qual esses erros estão acontecendo. Para tentar resolver esta situação, foi sugerido um sistema chamado "sistema de coleta de dados" que permitirá reconher dados sobre as peças de reposição mal distribuídos, com o objetivo de melhorar o inventário.

Para a aplicação destes processos, foi sugerido um calendário com uma duração estimada, final, de 53 semanas.

Finalmente, para todos estes serem aplicados, não foram sugeridas políticas de qualidade que ajudarão a sustentar as mudanças através do tempo e facilitadoras da sua implementação.

Palavras-chave: Qualidade, código de barras, melhorias de processos, automação, armazem.

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List of abbreviations

CPO – Classification productivity by operator

CPOZ – Classification productivity of the operator in each zone

CPW – Classification productivity of the warehouse

CPZ – Classification productivity by zone

EAN – European Article Number

GPW – General productivity of the warehouse

GPZ – General productivity by zone

HPW – Handling productivity of the warehouse

IC – Items classified in the warehouse.

ICZ – Number of items the operator classified by zone

IP – Items picked in the warehouse.

IPZ – Number of items the operator picked by zone

IS – Items packed and sent in the warehouse.

ISZ – Number of items the operator packed by zone

JIT – Just In Time

LPH – “Líneas por hora hombre” (Lines per hour per man)

ppm – Parts per million

PPO – Picking productivity by operator

PPOZ – Productivity in the picking process for each operator in each zone

PPW – Picking productivity of the warehouse

PPZ – Picking productivity by zone

RFID – Radio frequency identification

SKUs – Stock Keeping Units

SPO – Sending productivity by operator

SPOZ – Sending productivity of the operator in each zone

SPW – Sending productivity of the warehouse

SPZ – Sending productivity by zone

TC – Time used for classifying the items.

TCI – Total number of items that the operator classified

TCP – Toyota Caetano Portugal

TDV – Toyota de Venezuela C.A.

TP – Time used for picking the items.

TPI – Total number of items that the operator picked

TPS – Toyota Production System

TS – Time used for packing and sending the items.

TSI – Total number of items that the operator packed

UCC – Uniform Commercial Code

UPC – Universal Product Code

VTU – Volvo Trucks

W/H Denial – Warehouse denial

Glossary

Spare part: Individual pieces that are stored in the warehouse.

Item: Specific type of pieces which are stored in the warehouse. It contains several spare parts. Ex: Front bumper of Corolla 2007.

Franchise: From the Toyota classification the franchise refers to the company from which the items are coming from. In Toyota de Venezuela there are three franchises: Toyota, Daihatsu and accessories.

Route: Is defined in TDV as the process which the items for a certain group of dealers are picked, packed and sent.

INTRODUCTION

The automotive industry is a challenging and competitive industry. Any advance that can be obtained in any stage of the supply chain will help the company to serve better the costumers and will result in higher benefits.

One of the areas of the supply chain where companies may obtain a strategic advantage is warehouses. That is why, Toyota de Venezuela C.A (TDV) is trying to improve the operation in their warehouse to reduce costs and improve the quality of the operation.

This work is focused in present a proposal for the automation of the dispatch process from the warehouse of spare parts of TDV. With this it will be improved the quality and productivity of the operation, helping to create higher benefits to the company and increase the client's satisfaction.

These improvements will be made based on information gather from the warehouse of TDV. The warehouse of Toyota Caetano Portugal (TCP) will be used as reference for the improvements, because it has more advanced procedures in the warehouse.

The work is divided in six chapters:

- Problem statement: This chapter will present the companies, giving an explanation about their functioning. About TDV it will be presented the processes they make now, the main characteristics of the warehouse and a description of its zones. From TCP it will be given a description and some basic information about their processes. Then, it will be presented a brief about the philosophy of Toyota to understand better how this company is managed. After this, it will be presented the proposal that was made by TDV with the reasons that made them propose it. Finally, it will be presented the objectives of this work to have a clear idea of what will be given to the company.
- Theoretical framework: This section includes the basic theory used in this work. It talks about warehousing, warehouse management and warehouse management systems. Basic theory about the functioning of barcode and information about the barcode scanner that will be used in TDV. It will also be presented a brief literature review about the use of barcode scanners in the automotive industry and about the use of RFID in the same industry. Finally, it will be presented the methods that are used to evaluate the data in this work (Pareto chart and cause-effect diagram).
- Data collected: In this section is included the data collected from both companies. It is included the information about the different errors that are made during the operation of the warehouse, the processes done for both companies, information about the productivity in TDV's warehouse and information about the inventory management in TDV to better understand the operation.
- Data analysis: In this section is the analysis of the data that was received from both companies. The objective of this is to establish similarities and differences in the operation of both companies and to analyze the processes to establish objectives for each one of

the new processes and improve them. Also, try to find the root causes that are generating errors in TDV's warehouse to try to solve them.

- Proposal solution for improvement of TDV's warehouse: In this section is presented the proposal that is being done to the TDV warehouse. Here are presented the new processes that will be applied in the warehouse, the new improvements that will be necessary to apply the processes, the new indicators that will be used to evaluate the operation and some suggestions that will help to keep the improvement of the operation.
- Recommendations and conclusions: it will be presented the recommendations that will be appearing during the work to improve the general operation of the warehouse, and the final conclusions that were driven from this work.

CHAPTER I

PROBLEM STATEMENT

1.1 History of Toyota de Venezuela C.A. (TDV)

In Venezuela the Bilbao brothers, of Cuban origin, establish conversations with Toyota, starting the distribution of cars in Caracas (Bello Monte). The lack of experience in the automotive industry makes them sell the franchise to the entrepreneurs Carlos Siso Paván and Alfredo Behrens, who make an agreement with the firm Toyota Motors Company from Japan, to continue the import and distribution in Venezuela of the cars Toyota Land Cruiser FJ-40 with canvas roof, being founded the first of December of 1957 the company Tocars, C.A.

In 1963, by presidential decree, is forbidden the import of cars, which force Tocars, C.A., to contract the services of the company “Ensamblaje Superior” located in the Sucre de Catia Avenue Caracas, to assemble the FJ-40 cars with canvas roof and the FJ-45 pick-up, in the direct supervision of Tocars, C.A., becoming in the first assembling plant of Toyota outside Japan.

The branch Toyota starts to penetrate the automotive Venezuelan market in a steady pace, showing quickly a sustained increment in the demand of their products, what made insufficient the infrastructure of the company “Ensamblaje Superior”. This situation takes the directive of Tocars search for alternatives that allow continue their operations, adjusted to the new production volumes that the market is demanding, and the forecast.

In this sense Tocars, makes contact with the company “Indemaca”, assembling company of the trucks International, locates in the city of Maracay, Aragua state, which had big infrastructure that allowed the incorporation of new assembling lines. For 1970 starts the assembling of Toyota in Indemaca, adding two new models corresponding to the series: HIACE and FJ-55.

In 1979, motivated by an agreement with the Ministry of Development and Tocars, start the evaluations that take to the construction project of an assembling plant for cars and lifts in the city of Cumaná, Sucre state, counting for that with the financing of “Fondos de Inversiones de Venezuela” (F.I.V).

The 21 of November of 1981 officially start the assembling operations in the Cumaná plant, being the president Mr. Francisco Paván; appears a new model, the truck Station Wagon FJ-60. In the month of April of 1986 finishes the contract with the company Indemaca, producing the total moving of the process of assembling to Cumaná. In that year, start the assembling of the passenger vehicle Toyota Corolla, which is a determining factor in the consolidation of Tocars as assembling company.

In the year of 1989, the economic situation of the country was seriously affected by changes in the governmental policy, producing an accentuated and progressive devaluation of our monetary sign, which motives the search of external financing to accomplish with the contracted obligations and to avoid, the close of the plant. Toyota Motor Corporation, conscious of the situation and thanks to the

extraordinary commercial relationships kept with the company Tocars by a space of thirty two years, accepted the challenge of being the financial entity, becoming in the bigger partner of the company.

1.2 Warehouse of Toyota de Venezuela C.A. (TDV)

The Toyota de Venezuela's warehouse of spare parts is located in the city of Caracas. It has 4450m^2 of physical space with an extra 500m^2 destined to administrative areas. This warehouse is in charge of receiving all the spare parts that are sent to Venezuela from Japan, Brazil, USA and other countries, store them and, when requested by the dealers sent them to the different parts of the country; supplying to 66 dealers in all country. In total, this warehouse has 91937 items storage where the amount storage for each item is to cover 4 months of demand (Toyota de Venezuela C.A, 2011).

1.2.1 Warehouse zones

The warehouse of TDV is divided in 16 zones according to the type of spare part that is located there and the necessary tool to allocate and pick up in them. They are explained in the annex 2. Each area of the warehouse is divided in halls, where each hall is classified according to a letter to differentiate the type of location and a number in an increasing mode to differentiate the halls; inside each hall there are a number of shelves, identified by a letter in an increasing mode. Finally, in each shelf there is a certain amount of rows identified by letters from top to bottom, and in each row there is a certain amount of locations identified by numbers from left to right. An example of a location identification number is (figure 1):

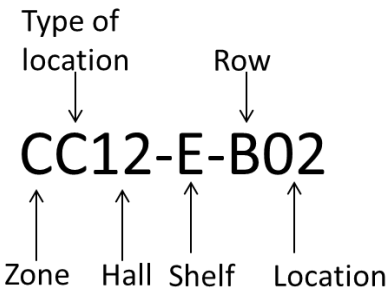


Figure 1 Example of a location of the warehouse.

1.2.2 Dispatch operation

For the dispatch of spare parts, the warehouse works with 10 routes per day distributed like shown in the routes diagram (Annex 1). Each route is initiated every 40 minutes; starting the work at 8:40am, with an hour between the fourth and fifth route for lunch, and two coffee breaks between 9:00am and 9:15am and the second one between 2:00pm and 2:15pm.

The dispatch operation is divided in 6 operations:

- Closing of orders: The dealers have until a certain hour in their respective route to request the items, according to the inventory in the warehouse.
- Printing of bills and picking labels: The bills are printed with the dealers' request, and the picking labels for the picking process are organized and printed.
- Work assignment: The picking labels and the packing of spare parts are distributed between the workers.
- Picking: The picking process is done by the employees where they collect what will be sent in that route.
- Classification: The items collected are classified according to which dealer they will be sent.
- Packing: The employees pack the items as they cross check with the bill to see if they are sending what was requested and the packs are put in trucks and sent to the different dealers.

1.3 Toyota Philosophy

1.3.1 Toyota Way

The Toyota Way is a standard guide for the distributors, assemblers and sellers. It base is the continuing development reducing wastes. It was developed by Kiichiro Toyoda whom, constantly, encouraged his operators to make suggestions (Toyota de Venezuela C.A.).

The Toyota Way has two main pillars which are the continuous development and the respect for people.

The continuous development has it bases in: challenge, "Kaizen", (Continuous improvement at the lower cost) and "Genchi Genbutsu" (Problems solving).

1.3.1.1 Continuous improvement

It refers to constantly try to be better. It is based on the challenge, "Kaizen" and "Genchi Genbutsu".

The challenge (Toyota de Venezuela C.A.)

At personal level, it refers to accomplish the goals using long term vision with bravery and creativity. It is to observe beyond the moment and see what the future can bring us. With this, prepare itself to the best way to overcome it.

At business level it is about:

- Create value through the manufacture and delivery of products and services.

- Keep a competitive spirit with the workmates.
- Have long term perspectives.
- Take good decisions through the reflection and discussion.

"Kaizen"

It refers to the continuous improvement at the lower cost. At business level it is:

- To adopt a "Kaizen" mentality and innovator thinking.
- To build systems and structures those support each other.
- To promote the learning as organization.

"Genchi Genbutsu" (Toyota de Venezuela C.A.)

It refers to go at the place of the problem to collect data that allows take the correct decisions. With this, develop the consensus to accomplish the goals. It is to collect data and through the solving of problems do improvements in time. At business level:

- To build effective consensus.
- To commit with the achievements.

1.3.1.2 Respect for the people

It refers to build solid relationships between the workmates through the respect and the team work.

Respect (Toyota de Venezuela C.A.)

When we respect and understand the others we take the responsibility to build mutual trust. We must respect all the workmates, for developing mutual trust, to develop mutual responsibility and be always effective sincere and communicative.

Teamwork (Toyota de Venezuela C.A.)

It must stimulate the personal and professional growth, and share the opportunities of growth to maximize the personal and team development. The person must compromise with the education and the personal development, respect the individual and consolidate the power that can be developed as a team.

1.3.2 "Muda" (Wastes)

"Muda" is a Japanese concept that refers to the wastes produced in a process. According to the Toyota's philosophy the "Muda" has seven origins which are:

- By low efficiency: This is given by errors in the processes.

- By low system's quality: This appears when part of the material must be storage waiting for information.
- By time's fluctuations: When the order of the necessary material is not reaching on time.
- By movement: This appears when it is necessary to cover big distances during the process.
- By lack of synchronization between two operations: When some material has to wait time before being able to pass to the next stage of the process.
- By transport: When must be storage material given the inefficient transport's system.
- By big batch: It refers to when a material's batch must stay in wait given that the system doesn't have the capacity to process them on time.

As it can be seen, the concept of "Muda" doesn't refer just to the physical wastes. It also refers to the waste in storage's space and in processing time. According to this, reducing the "Muda" the process become more efficient, require less space and consume less material.

The concept of "Muda" is not an isolated concept; this is related with two other Japanese concepts which are: "Mura" (Work's fluctuation) and "Muri" (Excess of load). "Mura" refers to the work load's fluctuation for the operator in standard terms. "Muri" refers to the excess of load in the mind and body of the operator.

The conjunction of those three elements defines the 3 Mu. They define, in its totality, those aspects that can alter in a negative way a process. With the reduction of the "Mura" there are more stable working times and, with the reduction of "Muri", the operator can work in a more efficient and calm way.

1.3.3 The 4S

The 4S are activities that are realized to achieve a secure environment and that improve work. These activities are based in the reduction of "Muda" with the end of keeping the area in good conditions for the realization of the warehouse's activities. The 4S, in Japanese, are "Seiri" (Classify), "Seiton" (Organize), "Seisou" (Cleaning) and "Seiketsu" (Self-control).

The 4S are explained in the next way:

- "Seiri": Classify the objects on necessary and unnecessary to undo or reuse those that are unnecessary.
- "Seiton": Organize the necessary things by its use, its frequency of use, place of use and shape to decide where and how to store it.
- "Seisou": Keep everything clean.
- "Seiketsu": Keep the good state of those things that have been classified, organized and cleaned.

To fulfill with the 4S give us an area of clean and organized work, that allows realize the activities in the most efficient way possible. At the same time increase the security, putting all the things in the places where they don't represent a risk for the individual.

1.3.4 "Toyota production system" (TPS)

The objective of the TPS is to reduce the logistic costs through the elimination of "Muda". The TPS has two main pillars: Just in Time (JIT) and "Jidoka" (Control of irregularities).

The JIT refers to reduce the "Muda" through the increase of the efficiency in the work, producing and transporting just what is necessary when is necessary (Toyota de Venezuela C.A.), and "Jidoka" refers to the regular control of the irregularities, which is realized with the stop of the process so the irregularities can be noted and can be improved by "Kaizen" activities.

1.4 TDV's types of errors

The dispatch process is subjected to the mistakes that can be committed by the operators in the different processes. For instance, in the picking process the operators may pick up the wrong item or the wrong amount (these errors are considered mispicking). They may not find the item they are looking for because of a mistake committed by another operator (this error is considered denial). Finally, it is possible that one of these errors filters through to the dealer, in which case it would be considered misshiping.

When these errors occur and they are detected inside the warehouse they cause a waste of time for the operators to correct them; also, if they arrive to the dealer they will affect the image of the company and will increase the time to serve the clients, reducing the service level of the company and the clients' satisfaction.

1.5 Proposal made by TDV

The errors described before are situations that the warehouse should try to reduce to a minimum level so the operation can be the most fluent and efficient as possible. That is one of the reasons why the management of the warehouse would like to automate the process implementing a barcode scanner. This would allow them to reduce the quantity of errors committed by the operators, and keep a record of all the errors so that the management is able to analyze them and find a solution.

Another issue the management wants to eliminate is an administrative process called "credit notes". Normally, after a dealer orders an item, this one is billed to the dealer but if the item is not found in the warehouse is necessary to register the shortage of this item because it is already billed. Under this situation the warehouse is losing time of one operator that has to introduce the credit note and be sent in the next day to the dealer. This task does not add any value to the process because those items that are registered as credit notes are not sent later, that part of the order is cancelled and

is only sent if the dealer asks for it again. Having this in consideration, another idea from the management is to change the process to a supermarket billing style, where the order is received from the dealer but is only billed what is found in the location, eliminating the existence of credit notes.

With these two concepts in mind, the warehouse management has in mind to automate their dispatch operation using a barcode scanner to reduce the errors committed by the employees, modify the processes so the supermarket method for billing can be applied and use the scanner to improve the technique of data collection so the improvement of quality turns easier and more efficient.

1.6 Toyota Caetano Portugal (TCP)

The warehouse of spare parts of Toyota Caetano Portugal is located in Vila Nova de Gaia: it has 11064m^2 of physical space where 520m^2 are destined for administrative area. This warehouse is in charge of receiving the spare parts for Portugal and the areas of Spain known as Galicia and Andalucía, where Toyota has 117 dealers, 64 in Portugal and 57 in Spain. In total this warehouse has 59000 items in stock for 25 working days (Toyota de Portugal, 2011).

The process starts at 8.30 am, when the warehouse receives the orders from the dealers, until midday if they are from Spain and until 4:00pm if they are from Portugal. They send the parts to the dealers at 5:30pm.

The dispatch operation is planned according to the spare parts required by each dealer. The picking process is planned according to the distribution areas in which Portugal and the areas of Spain that are being served are established. The picking cycles are planned for a 15 minutes picking, where the small and medium sizes items are picked and then packed according to the specific dealer they are destined to.

1.7 Objectives

1.7.1 General objective:

- Develop the new logistic process for the shipment of spare parts using a barcode scanner as main tool in the warehouse.

1.7.2 Specifics objectives:

- Develop the new process for the picking of spare parts using the scanner.
- Develop the new logistic for billing the orders, considering the elimination of credit notes, billing the spare parts that are picked.
- Develop the new process for the packing of spare parts using the scanner.

- Creation of a system that allows the collecting and analysis of the differences between dealers' orders and the spare parts sent (service level indicator).
- Develop a new process using the scanner as main tool that allows the supervisor collects information about the errors committed in the allocation of spare parts to create statistic (key performance indicators), to take counter measures and make KAIZEN improvement activities.
- Evaluate quality's policies for the analysis of the new data collected, so the warehouse can apply the KAIZEN system to improve the process.
- Design the new route diagram of shipping to the dealers that adapts with the new logistic in shipping.
- Design the program that allows calculating the productivity measure, in lines per hour per man (LPH), through the use if the scanner.

CHAPTER II

THEORETICAL FRAMEWORK

2.1 Warehouse management

2.1.1 Warehousing

Warehouses are defined as the function of storing a variety of product types that have a small or large quantity of storage units between the time that the product is manufactured and the time that the product is required by a customer or by a workstation within your manufacturing facility (Mulcahy, 1994). This makes the warehouse an important unit in the supply chain, developing several tasks through the different processes that they perform.

2.1.1.1 Warehousing processes

The correct organization of the warehouse and the correct development of the processes done will help to keep the whole operation in a normal workflow. For the control of this, the warehouse management has to evaluate the performance of 4 base processes (Heizer & Render, 2008):

- Receiving the material: In this process the warehouse receives the materials and introduce them into the system. The main point here is to register all the incoming material in order to have the knowledge of what is inside the warehouse. An error here can make the company have the wrong concept about what they really have and make them ask material when they do not need it, or lose a sale when the company actually has the material.
- Location of material: After the material is received it has to be located inside the warehouse. If the materials are not well located the warehouse will sell material that cannot be found, and this will produce problems in the shipment.
- Order preparation: For the preparation of the order the warehouse needs to know what they have to sell to the clients. If they don't know well what they have they can sell what they don't have or they can avoid selling what they have.
- Shipment of material: After collecting the materials they are put together to be sent to each client trying to reduce the size of the shipment. If this process is not well done, the warehouse can send materials to the wrong client.

2.1.1.2 Value-added warehousing

There are several types of warehouses in the supply chain, with different methods to add value to the operation. The different types of warehouses are (Frazelle, 2002):

- Raw material and component warehouses: Keep the raw material near a production point.
- Work-in-process warehouses: Hold semi-finished products in several points of the production system.
- Finished good warehouses: Keep inventory of finished products as a buffer point to respond at the variation of the demand.
- Distribution warehouses: They receive the products from several production points for combined shipment to common customers.
- Fulfillment warehouses: Respond orders for individual consumers.
- Local warehouses: Located near the customers for rapid responses, shortening the transportation's distance. For servicing in less than 24 hours.
- Value-added service warehouses: Is a warehouse where key product customizations are done, like labeling, pricing and packaging.

2.1.2 Warehouse management

Due to significant change in global business environment, a warehouse does not only perform as a storage area, but as a multi-function operation center such as distribution center or packing center (Lam, Choy, & Chung, 2010).

This establishes the warehouse as a middle point of the operation that works as a buffer between two processes. This condition makes them as one unit that requires high operating efficiency. This is why the main objectives of the warehouse management are to reduce costs and improve operation's time to respond in the best way possible to the customers' demands.

To improve the processes the warehouse management must evaluate the following aspects (Tompkins & Smith, 1998):

- Customer service: This must be the basic concern of the management. The warehouse management must always try to respond at the highest amount of customers.
- Control systems: Here the management must evaluate how information is stored, how the system responds to special requests and what material is produced to support the data.
- Inventory accuracy: It is important that the management has the necessary inventory and that the inventory is well registered so all levels of the supply chain may have the necessary information.
- Space utilization: It is important to check that the space in the warehouse is being used properly.
- Labor productivity: It is important to analyze the performance of the personnel and their use of their working time.

- Facility layout: It is importance to analyze how well is the inventory distributed and the effect that the distribution of the inventory has over the performance of the operators.
- Equipment methods: In the warehouse, the equipment must be used properly. If the equipment is used correctly it will last longer and the operation will be easier and safer.
- Equipment utilization: This is calculated by each type of equipment, and it is important for knowing which the key equipment in the operation is.
- Building facilities: It must be evaluated factors as lighting, personal services (like bathrooms and resting areas), fire protection, dock capability, catering and others.
- Housekeeping and safety: The safety measures are compared with the standards established by the company and by the government.

Rating these aspects will help the management to have a clear idea of the warehouse performance. This will help to know it actual state, what improvements do and which are the strong and weak points in the operation.

2.1.2.1 Challenges for warehouse management

Currently, warehouses do more than storing goods: they need to perform more activities and at the same time improve their processes. From this, the warehouse manager it is asked to establish higher objectives as the base to develop the operation. These objectives are (Frazelle, 2002):

- Execute more, smaller transactions.
- Handle and store more items.
- Provide more products and service customization.
- Offer more value-added services.
- Process more returns.
- Receive and ship more international orders.

But at the same time, today the warehouses have (Frazelle, 2002):

- Shorter times to process orders.
- Smaller margins of error.

Improving the operation performance may lead to increase in customer satisfaction. Therefore, it is necessary to measure the warehouse operation performance continuously to evaluate the service level and operation efficiency of the warehouse (Lam, Choy, & Chung, 2010).

2.1.3 Warehouse management system (WMS)

For the correct performance of the processes it is necessary a system that allows the warehouse management to organize their personnel and to establish the best flow possible of material through the process. For this, the warehouse management has the support of warehouse management systems.

Warehouse management system provides, store and reports the information necessary to efficiently manage the flow of products within a warehouse, from the time of receipt to the time of shipping (Faber, Koster, & Velde, 2002)**.**

This system will allow the warehouse management to sign in the orders they receive from their clients. So with this information they may plan their picking and shipment operations. The main function of WMS is to manage the inventory through tracking the movements of products, storing of materials within a warehouse and sharing accurate inventory information with the client (Kim, K.H., & J., 2008)**.**

2.2 Technologies used in inventory control

2.2.1 Barcodes

The barcode is a technique to sign in data with images made by combinations of parallels bars and spaces of different width. This lines and spaces represent numbers that can be readied and decoded by optical scanners. This code is useful to identify the products in a unique way because allows to connect a product with some specific data gather in a data base.

This system is commonly used in all the levels of the supply chain, basically because if we compare and operator introducing the number of the piece and an scanner reading it we get that in average the operator makes 1 error for each 300 numbers introduced, while the scanner makes one wrong reading in a trillion of codes read (Sabater, 2003).

Basically, the code works by assigning numbers (according to the system) to a certain amount of lines and space, where lines represent 1 in computer language and spaces represent 0. With this, the code in general (see figure 2) has a beginning that helps to define the space between each line to establish how many lines are actually represented in the image. With this first part of the code the system establishes the long that each line has and then translates the information in the code to the numbers or letters that they represent to singing in the computer.

Figure 2 Linear barcode

For the reading of the barcodes it is necessary the use of some optical scanners that can “translate” the bars in the specific numbers or letters that they represent. In general, they emit a light that reflects the patterns of the lines in the code that then are transformed in an electrical signal that is transformed in the 0 and 1 that are interpreted by the computer, to give the real information written in the barcode. There are different types of scanners that may need or not to enter in contact with the barcode to read it. A common example of the scanners used can be seen in figure 3.

Figure 3 Scanner CD3000AK / PS2

More recently there are two-dimensional barcodes that allows storing more information, and with this differentiate a larger quantity of products. These codes follow similar principles than the one dimension codes.

Since 1970 several organizations in Europe (EAN) and USA (UCC) have as objective the standardization of the barcodes using a more universal system, where the most common code is called Universal Product Code (UPC). With the use of a universal code we can use the barcode system in every part of the world to identify that component properly.

2.2.1.1 Barcodes in automotive industry

One field where barcoding has really taken off, and where there is enormous potential, is in the automotive industry (Alberta, 2011). Barcodes provide an efficient and effective way to manage materials at all stages of the supply chain, a process that often proves to be a challenge in the automotive industry (Alberta, 2011).

In the literature review is not much information about the use of barcode. The main reason for this is that the new investigation is focused in the use of radio frequency identification (RFID) in the several stages of the supply chain. But, there are still only a few RFID applications centered on the fully automatic identification of objects to improve warehouse operations (Cao, Folan, Mascolo, & Browne, 2011).

But the use of the barcodes in inventory management is quite extended in Toyota, where since the Japan the spare parts are sent with barcodes to the rest of the world.

2.2.1.2 Barcode scanner

The main tool for the realization of this work is a portable barcode scanner. The model of scanner that was acquired in the TDV warehouse is the Symbol MC-3000 In the figure 4 can be seen the components of the scanner.

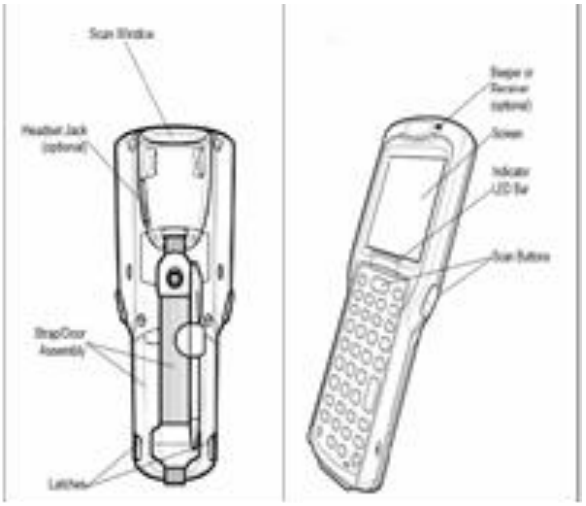


Figure 4 Diagram of the scanner Symbol MC-3000

The main parts that can be seen in the figure are:

- Scan windows: In this area is located the light that emits the scanner to scan the barcodes.
- Screen: Is the scanner's touchscreen in which it can be seen the barcode's lecture and that allows the interaction of the user with the scanner.
- Indicator LED's Bar: This light indicates when the scanner is in the process of scanning a barcode
- Scan buttons: With the use of any of these buttons it is started the scanning process.

In figure 5 it is possible to see the picture of the scanner used in TDV warehouse. In this picture we can see the scan buttons, the touchscreen, the indicator light and the keyboard used to input data manually in the scanner.

This scanner also has a pencil which allows manipulate the screen of the scanner and a battery which gives the autonomy necessary to be used in the warehouse. The program which the scanner is being controlled is done by the department's system of TDV. This allows that the scanner can be constantly adapted to the requirements of the processes.

Figure 5 Scanner model Symbol MC-3000 from TDV.

2.2.2 Radio frequency identification (RFID) in automotive industry

RFID is a technology that uses radio waves to identify objects. Since the first RFID technology was developed by the Los Alamos Scientific Laboratories in 1977 it has seen increased usage from animal tracking and toll collection, to supply chain management (Cao, Folan, Mascolo, & Browne, 2011).

In the automotive industry the use of the RFID has been extending. Toyota has implemented RFID systems to track engine/parts production and painting in French and South African facilities (Cao, Folan, Mascolo, & Browne, 2011). Volvo Trucks (VTU) initiated an RFID system on the detail racks in its paint shop in its plant of Umeå, Sweden as early as 2000 (Fasth, Johansson, & Karlsson, 2005). BMW have implemented RFID-based real-time location systems in four of their German plants (Collins, 2005).

We also have other companies, like Volkswagen, that have implemented the RFID tags to track the vehicles that enter in their facilities and to have instantly the status of the vehicle (IDENTEC SOLUTIONS, 2005). And Ford, which uses the tags to check the battery's charge of the electric forklifts placed in 42 plants in North America (Swedberg, 2005).

It is able to see that the examples presented show how the use of RFID tags is extending in the automotive industry in several applications, going from the production area to the service system.

2.3 Tools for process analysis

2.3.1 Cause-effect diagram

When we are analyzing a situation it is always possible to find several possible reasons to explain a problem. Organizing these reasons can help to have a better idea about which is the root cause involving the situation. With this idea, in 1953, Kauro Ishikawa summarized the engineers' opinion of a company in the way of a cause-effect diagram while discussing a quality problem (Kume, 2002).

A cause-effect diagram is a simple graphic method to represent a chain of causes and effect, and also classify the causes and organize the relations between the variables (Evans & Lindsay, 2008).

The cause-effect diagram is represented with a base line that is the effect; coming from this line we have several lines that represent the main causes considered. From these lines we have the specific causes that are being considered. An image of a cause-effect diagram can be seen in figure 6.

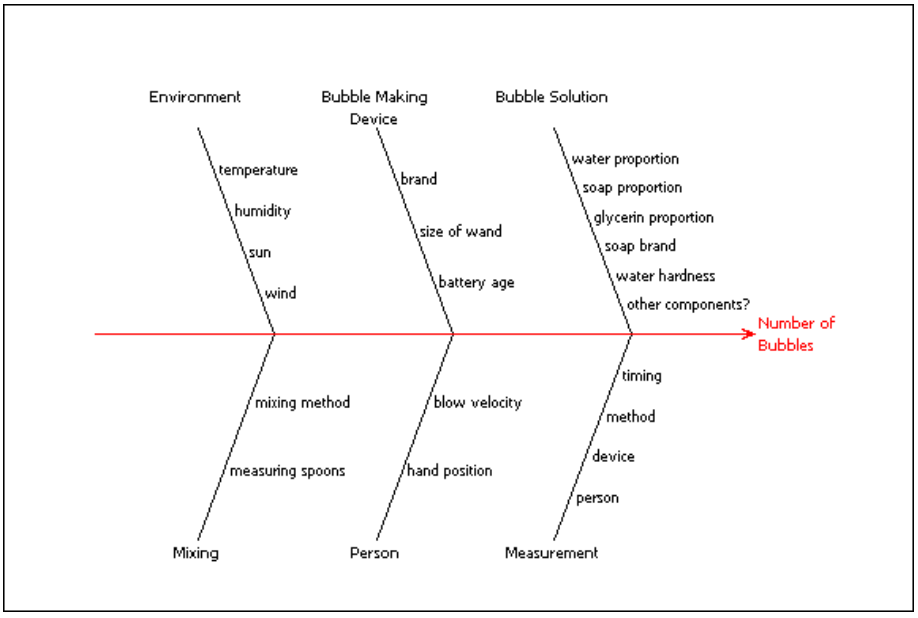


Figure 6 Cause-effect diagram.

This method is used to organize the possible causes that might create a certain situation; this organization will allow make a clear idea of the situation considered. The process to perform a cause-effect diagram is (Kume, 2002):

- To describe the effect that is being analyzed.
- To look for all the possible causes that may be influencing this effect.
- To group the causes by the affinity they have with each other and elaborate the cause-effect diagram connecting those elements that seem to have an important influence over the effect.

- To assign the importance of each factor, and point the factors those seem to have a big influence in the effect.
- To write any information that may be useful.

2.3.2 Pareto chart

In 1897, the Italian economist Vilfredo Pareto presented a formula that showed that the distribution of the income is unequal. In 1907, the economist M. C. Lorenz expressed a similar theory through diagrams. Meanwhile, in the quality control's field, Dr. J. M. Juran applied the method of Lorenz's diagrams as formula for the classification of the quality problems as few vitals and many trivial, and called this method Pareto analysis (Kume, 2002).

The Pareto principle establishes that most of effects, around 80 percent, are produced by 20 percent of the causes (Andersen & Fagerhaug, 2006). Follow this approach is very useful for solving problems, establishing a narrow amount of causes that should be attacked with the objective of solving a problem. The Pareto charts are used to graphically show the bases of this principle and easily take the causes that represent the highest problems.

The Pareto chart is a bar's graphic, where the bars are organized from left to right from the highest value to the lowest; in the left side the "y" axis measures the amounts measures and in the right side the "y" axis measures the percentage. From the top of the first bar is created a line that accumulates the percentage of the bars, arriving to the last bar marking the 100%. A representation of a Pareto chart can be seen in figure 7.

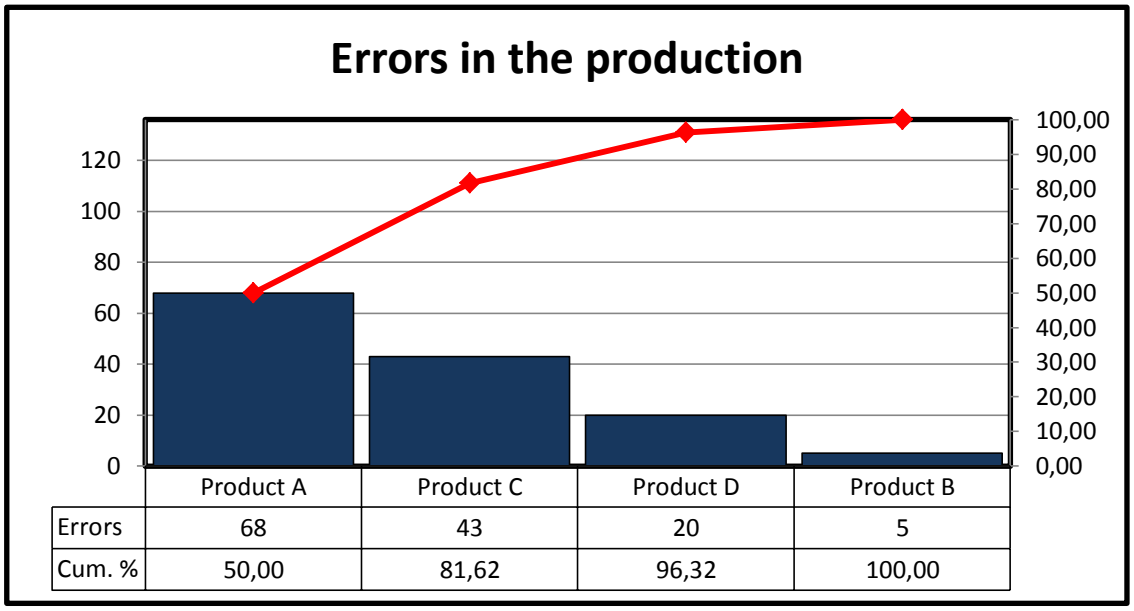


Figure 7 Pareto chart.

For the realization of a Pareto chart the process is (Andersen & Fagerhaug, 2006):

- To define the process that will be analyzed and the potential causes.
- To define the criteria that will be used to compare the possible causes.

- To define the time interval for the data collection and collect the data.
- To place the causes from left to right from the most repetition to the less. Draw rectangles to mark the repetition of each cause.
- To mark the data value on the left and the percentage on the right and draw a curve that represents the accumulative repetition of the causes.

CHAPTER III

DESCRIPTION OF THE PROCESSES AND DATA COLLECTED

3.1 Dispatch operation in the warehouse

3.1.1 Toyota de Venezuela C.A. (TDV)

There are four main processes in the dispatch operation at the warehouse of TDV. These four processes are done manually. They are:

- Preparing of picking cycles for the operators.
- Picking of spare parts.
- Classification of the spare parts according to the dealer.
- Packing of the spare parts to be sent to each dealer.

At the beginning of the operation of the warehouse there was a group of operators assigned to each process. Each group has a time frame to complete it process to deliver the spare parts to the next one. This produced that, during each route, each group had a time frame in that they were waiting for the previous process to finish it work.

This delay made the operators have periods of inactivity followed by periods of intense work. This is an inefficient method to run the warehouse operation because of the wasted time that each operator had.

Since 2009 the processes of picking, classification and packing are done by all the operators. These means that each operator picks items in it designated zone, after he starts to classify the trolleys with the spare parts. Finally, he starts the process of packing the dealer that was assigned to him.

This method makes that all the operators be constantly working, increasing the working time that each operator has; but also increasing the time that they have for doing it because each operator has less work to do in a larger time frame.

3.1.1.1 Picking cycles' preparation

In this process the information from the dealers in each route is taken by the system and it is established the work for the warehouse's dispatch operators. The procedure followed in this process is:

- The list of items ordered by each dealer is received.
- The items are divided by area of the warehouse.

- The items from the area of mezzanine are organized by dealer and inside each dealer they are organized according to the location of the items in mezzanine, from the first location to the last.
- In the case of the rest of the warehouse, the items are organized according to location from the first to the last, without considering from which dealer is each picking label.
- The picking labels are impressed, showing all the necessary information for the operator locate and identify the item.

After this process is done an operator takes the picking labels and creates “working cycles”, separating the picking labels according to the following statements:

- If the picking labels are from mezzanine they are separated according to each dealer without paying attention to the amount of picking labels that are assigned in each working cycle.
- For the rest of the warehouse they are separated in groups of a top of 40 labels and considering a top of 10 minutes per working cycle. The amount of picking labels is defined according to the zone in that they are located.

Then each zone or dealer is assigned to one operator, so he picks all the items. This distribution allows have a clear tracking of the operator that is working each zone or dealer, avoiding confusions and making easier the analyses of the errors.

Also, during this process the bills with what the dealers have ordered are printed. These bills will contain the accounting information necessary for the warehouse and for the dealer. Together with the bills are printed the “picking notes”.

The picking notes are used by the operators to compare the items that are being sent to each dealer against the ones he ordered. The picking notes also contain the information about in which box every item was packed, so the dealer will be able to rapidly locate the spare parts and to check for mistakes.

3.1.1.2 Picking

This is the process in which the operators go over the warehouse looking for the items that the dealers asked. The process is done according to the different stocking zones of the warehouse. This improves the efficiency and reduces the possibility of damaging spare parts.

The vehicles that are used for the picking of items vary according to the zone of the warehouse that is being picked: in zones where large parts are stored it is used a lift and in zones of small and medium sizes items trolleys are used. The procedure followed during this process is (Amorocho, SOP Recolección de repuestos pequeños, 2009):

- The operator takes the working cycle assigned to him.
- To locate the zone where he is going to pick.

- To identify the cycle with a marker so it is possible to know which operator did the picking.
- To go to the first hall where the picking will start.
- To go to the shelf which the picking labels indicates.
- To go to the location that the picking labels indicates.
- To extract from the location the amount of spare parts required by the dealer. If there are not enough spare parts check in the reserve.
- To put the spare parts orderly in the trolley and check if all the part number are the same.
- To proceed with the next picking label until the end of the cycle.
- When the picking is finished take the trolley to the classification area.

3.1.1.3 Classification

This is the process in which the items that were picked by the operators are distributed according to at the dealer that they are going to be sent. Large parts such as bumpers and doors are not classified. These parts are left in the paddle in which they were picked, and the operator in charge of packing the respective dealer will look for it and will register it as a “pendant”. The classification process follows the following steps (Amorocho, SOP Clasificación de repuestos medianos, 2011):

- To put the trolley in the area designated for the classification process.
- To take the item with the picking label from the trolley.
- To check, in the picking label, the part number and compare it with the one of the spare part to make sure that they are the same.
- To check, in the picking label, the amount ordered and to confirm that this amount was picked.
- To go to the shelf of the dealer that the spare parts are going to be sent and put all the spare parts in there.
- To put the spare parts with the part number pointing to the operator that will pack them.
- To repeat the process until classify all the items in the trolley.

3.1.1.4 Checking and packing

This process is the one where the spare parts are put in the boxes to be sent to the dealer. This is a critical step because any error made during the operation must be detected here, to avoid it arriving to the dealer. Each operator is assigned to one dealer, so he checks and packs all the spare parts from that dealer. In the checking and packing the process is (Amorocho, SOP Chequeo de repuestos medianos, 2011):

- To check which dealer the parts are going to be packed and sent.
- To take the picking note from the dealer and put it in the shelf.
- To look for the paddle and the box, and put it in the designated area.
- To identify the boxes with the number of the dealer.
- To organize the picking note's pages with the separators and put the number of the operator in all of them.
- To take one item with a picking label from the shelf and confirm that it corresponds to the dealer that is being packed.
- To check in the picking label the number of the bill and look for this between the picking note's pages.
- To check for the part number in the picking label and look that one in the picking note.
- To check that the part number of the item is the same than in the picking label.
- To check in the picking note the amount required and picks up that amount form the shelf.
- To write in the picking note at a side of the amount the box in that the spare parts are being packed.
- To put in the box the amount of spare parts that was checked.
- To follow this process until finishing packing all the items.
- To close the box, check that all items were packed and put the paddle in the area for dispatch.

3.1.1.5 Mezzanine

The zone called mezzanine is located in the upper floor of the warehouse. In the classification of zones this is considered zone 1. In this area is where the small sized parts are stored. According to the TDV's business report in 2010 this zone represents 49% of the sales' share of the warehouse. This level in the sales has been common since the starting operation of the warehouse, making this zone the most important in terms of sales.

Before 2009, this zone was worked as any other of the warehouse; the items were picked in baskets, sent to be classified and finally packed. This produced a high risk of the spare parts getting mixed up because their small size, creating mistakes during the classification and checking processes. This was up to the moment the highest problem in the warehouse.

This situation was improved pulling apart the work of this zone from the rest of the warehouse. The picking process passed to be done according to each dealer, and each operator after picking put the pieces directly in a box that will be sent to the dealer. This reduced the mistakes produced by the mixing of spare parts and increased the productivity of the warehouse by the focus of some operators

to work this zone. This new process required some changes in the preparing of picking cycles' procedure, adapting it so the picking labels were organized by dealer.

3.1.2 Toyota Caetano Portugal (TCP)

The warehouse of TCP does only one shipment of spare parts at the end of the day. The process is divided in:

- Preparation of picking cycles.
- Picking of spare parts.
- Classification of spare parts by area.
- Packing of spare parts by dealer.

In first place they have the picking cycles' preparation, which are done in Belgium by Toyota Europe. These cycles are planned by the area of Portugal or Spain where they are going to be sent. After, the cycles are digitally sent to the warehouse and they are put in a board by an operator. From this board the operators must take the picking cycles, having 15 minutes to complete each cycle.

Then, the spare parts are distributed according to which area, from Portugal or Spain, they are going to be sent. After the spare parts are separated by area they are classified and packed at the same time by one operator, to the different dealers that the items are going to be sent. For the packing there are plastic boxes each one identified by a barcode. The two main processes of the warehouse, picking and packing, are done by two separated groups of operators.

3.1.2.1. Processes of the TCP warehouse

Picking process (Toyota Caetano Portugal, 2011):

- For each work cycle is printed a label "work assignment".
- In the beginning of the cycle the picker reads the barcode from the "work assignment".
- The system will recognize the picking cycle from the "work assignment".
- Appears in the screen the first location and the part number of the item to pick.
- The picker takes the spare parts from the location in the correct amount.
- The picker reads the barcode of the spare part he picked.
- The picker puts the spare parts in the box and reads the barcode from the box (process of transferring the spare parts from the location to the box).
- Repeat until the end of the picking cycle.

Check/sort process (Toyota Caetano Portugal, 2011):

- In the “sort station” the operator reads the barcode of the box and the system identifies it content.
- To scan the barcode of one spare part.
- In the screen of the scanner will appear the dealer to whom the spare part will be sent.
- Put the spare parts in the box that will be sent to the dealer.
- Read the barcode of the box that will be sent to the dealer.
- Repeat the process until all the spare parts of the box are relocated to their destinies.

3.2 Key errors indicators

There are three main key indicators for the evaluation of errors in the warehouse of TDV. They are: mispicking, warehouse denial and misshiping. The mispicking and misshiping are created based on the information sent by the dealers, while the information from the warehouse denial is collected internally. The misshiping will not be considered here because it refers to spare parts that arrive damaged to the dealer and here there is a big influence from the transportation company used by TDV (Aerocav).

3.2.1 Mispicking

The mispicking errors are those made by the operators that filter through the checking process to the dealer. These errors refer to the difference between the information given by the warehouse about what they sent and the spare parts that the dealer actually received. In base on that, the objective of analyzing the data that refers to these errors will allow see the main aspects to be improved in the picking and checking processes, which are the main processes to prevent these errors occur.

The events that are considered as mispicking errors are (Toyota de Venezuela, 2010):

- Wrong part number: This is when the item that is sent does not correspond with the one ordered by the dealer.
- Less quantity than ordered: This is when the operator marks in the picking note that was a certain amount of that item sent but actually it was sent less.
- Missing item: This is when an item was allegedly sent, but there is no item received by the dealer.
- Excess quantity: Is similar to the case of less quantity but more spare parts are sent than those ordered.
- Other: Any other error that may have been made inside the warehouse when sending the spare parts.

The data provided about the mispicking errors is from the year 2010 divided in the different months of the year (Toyota de Venezuela, 2010).

Type of errors	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Less quantity	11	6	9	4	6	2	1	5	1	1	7	2	**55**
Excess quantity	3	6	3	3	3	0	0	0	0	2	1	0	**21**
Wrong part number	15	19	36	18	11	17	7	6	10	1	8	1	**149**
Missing item	3	6	8	5	1	0	1	3	2	4	2	1	**36**
Others	0	0	0	0	0	0	0	0	0	0	1	0	**1**
TOTAL	**32**	**37**	**56**	**30**	**21**	**19**	**9**	**14**	**13**	**8**	**19**	**4**	**262**

Table 1 Information from TDV about mispicking's errors in the year 2010.

3.2.2 Warehouse denial

Warehouse denial (W/H denial) refers to the situation which an operator goes to the location to pick spare parts and he does not find them, or he does not find enough in the location. This error is expressed in the warehouse as "credit notes". The data provided about the warehouse denial is from the year 2010 (Toyota de Venezuela, 2010).

Warehouse zones	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Zone 1 (A.)	13	34	29	100	72	26	5	11	21	22	17	16	**366**
Zone 1 (B.)	7	88	60	74	116	51	30	39	42	36	91	43	**677**
Zone 2 (C.)	13	41	61	58	36	29	27	11	21	28	26	22	**373**
Zone 2 (C.)	0	3	9	36	8	3	5	8	8	8	15	14	**117**
Zone 2 (D.)	1	8	17	12	14	1	2	2	4	2	2	1	**66**
Zone 3 (F)	2	15	14	17	11	11	7	3	9	5	3	0	**97**
Zone 4 (P-Q)	1	3	5	12	6	4	1	4	4	12	11	1	**64**
Zone 5 (Z)	2	1	3	0	2	3	0	3	2	5	1	2	**24**
Zone 6 (N)	12	29	42	35	46	19	17	8	6	13	11	32	**270**
Zone 7 (R)	0	0	0	3	0	0	0	0	0	0	0	0	**3**
Zone 8 (K)	0	0	0	0	4	0	3	0	0	0	0	0	**7**
Zone 9 (J)	0	6	6	2	12	1	3	6	4	49	15	8	**112**
Zone B (Bumpers)	45	150	136	111	138	29	65	140	177	68	9	13	**1081**
Zone 0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Zone A (Accesories)	0	1	1	3	3	2	0	0	0	0	0	0	**10**
Zone C(N7-N15)	7	11	16	6	10	5	3	15	5	8	6	7	**99**
Zone H/I(N7-N15)	10	25	48	25	14	11	22	56	25	14	9	6	**265**
Zone F(BARN 3 Y 4)	18	57	56	74	96	63	23	24	42	24	32	30	**539**
Zone X (XX)	0	0	1	1	0	0	0	1	0	0	0	0	**3**
TOTAL	**131**	**472**	**504**	**569**	**588**	**258**	**213**	**331**	**370**	**294**	**248**	**195**	**4.173**

Table 2 Information from TDV in the year 2010 about warehouse denial.

This table (table 3) shows the average per day, in 2010, of the warehouse denial in the warehouse, also the amount of days worked by month and the warehouse denial monthly (Toyota de Venezuela, 2010). Where the average is calculated as:

$$Average\ per\ day = \frac{Warehouse\ denial\ monthly}{Worked\ days\ in\ the\ month} \quad (1)$$

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Worked days	15	18	20	19	21	20	22	21	22	19	22	13	**232**
W/h denial	131	472	504	569	588	258	213	331	370	294	248	195	**4173**
Average per day	9	26	25	30	28	13	10	16	17	15	11	15	**18**

Table 3 Average of warehouse denials monthly for TDV in the 2010.

The next table shows the amount of spare parts and items that were billed during 2010 in the different zones of the warehouse (Alvarez, 2011), also expressed in percentage by zone, and calculated as:

$$\%Items\ (spare\ parts)by\ zone = \frac{Items(spare\ parts)by\ zone}{Items\ (spare\ parts)total} \quad (2)$$

Adding to this we have the amount of warehouse denial errors and the percentage of errors in each zone of the warehouse, calculated with the same formula (2).

Warehouse zones	Spare parts	W/H Denial	Items	%Spare parts	%W/H Denial	%Items
Zone 1	438705	1043	305990	32,49	24,99	35,38
Zone 2	269785	556	210337	19,98	13,32	24,32
Zone 3	4036	97	4076	0,3	2,32	0,47
Zone 4	9480	64	9530	0,7	1,53	1,1
Zone 5	2929	24	2969	0,22	0,58	0,34
Zone 6	162845	270	117115	12,06	6,47	13,54
Zone 7	60	3	59	0	0,07	0,01
Zone 8	555	7	564	0,04	0,17	0,07
Zone 9	32185	112	8035	2,38	2,68	0,93
Zone A (Accesories)	966	10	481	0,07	0,24	0,06
Zone B (Bumpers)	39580	1081	29315	2,93	25,9	3,39
Zone C(N7-N15)	15496	99	15016	1,15	2,37	1,74
Zone F(BARN 3 Y 4)	337429	539	139051	24,99	12,92	16,08
Zone H/I(N7-N15)	36185	265	22081	2,68	6,35	2,55
Zone X (XX)	142	3	146	0,01	0,07	0,02

Table 4 Percentage of warehouse denial, of items and of spare parts by area.

3.3 Productivity

The performance of the TDV and the TCP warehouses are being measured on the bases "lines per hour per man" (LPH by its acronym in Spanish). This indicator represents the amount of items (lines) that an average operator from the warehouse is processing during an hour of work. The formula for this statistic is:

$$Productivity\ (LPH) = \frac{Items\ billed\ in\ the\ month}{\sum_{i=1}^{n} Hours\ worked\ by\ operator\ i} \quad (3)$$

In the warehouse of TDV this statistic is made considering the amount of items that are being billed during a month of operation. For the quantity of hours is considered the amount of hours that each operator works, being established 6,25 hours for a normal operation day (8 hours, minus 1 hour for lunch, minus 2 brakes of 15 minutes and 15 minutes during the day to go to the bathroom) adding to this the extra hours that each operator works.

In base of that we can see the productivity data of the Toyota de Venezuela warehouse from 2010, including the average of worked hours by operator, the average of operators during the month and the amount of items billed in each month (Toyota de Venezuela, 2010).

	Jan	Feb	Mar	Apr	May	Jun
Items	71.786	80.872	90.002	99.107	106.205	62.424
Productivity	55,23	55,30	55,16	55,37	55,53	56,25
Operators	14	13	12	15	14	10
Hours by man	1.299,85	1.462,50	1.631,59	1.789,90	1.912,65	1.146,70
Worked days	15	18	20	19	21	20
	Jul	**Ago**	**Set**	**Oct**	**Nov**	**Dec**
Items	51.660	60.121	68.587	65.014	68.468	38.947
Productivity	55,57	55,94	55,90	56,01	56,14	56,24
Operators	7	8	8	10	9	12
Hours by man	920,50	1.074,75	1.227,00	1.160,80	1.219,69	692,56
Worked days	21	22	22	19	22	13

Table 5 Information about the productivity of the TDV warehouse in 2010.

3.4 Picking label

The picking labels are, in the present time, the main material produced by the warehouse to summarize the data about the dispatch operation. These are made from a special paper that has glue in the back so it can be stuck in to the spare parts. These labels are produced in special printers that have the necessary size to make them and the necessary characteristics to put the ink in this type of paper.

The information they have is related with the dealer that ordered the piece, the information about the location of the item in the warehouse and the information about the billing process that the item passed. The specific information contained in each picking label is in the table 6.

	Information
a	The zone of the warehouse where the item is stored
b	The location where the item is stored
c	The part number to identify the item including the franchise
d	The amount that needs to be picked
e	The route in which the item will be sent
f	The identification of the dealer's order
g	The dealer to which the items will be sent
h	The number of the bill where the item is registered
i	The location of that item in the bill
j	The date in which the item will be sent to the dealer
k	The country of origin of the item
l	Barcode with all the previous information

Table 6 Information contained in the picking label.

All this information can be seen in the picture below of a picking label used the 13 of May of 2011 in the TDV warehouse.

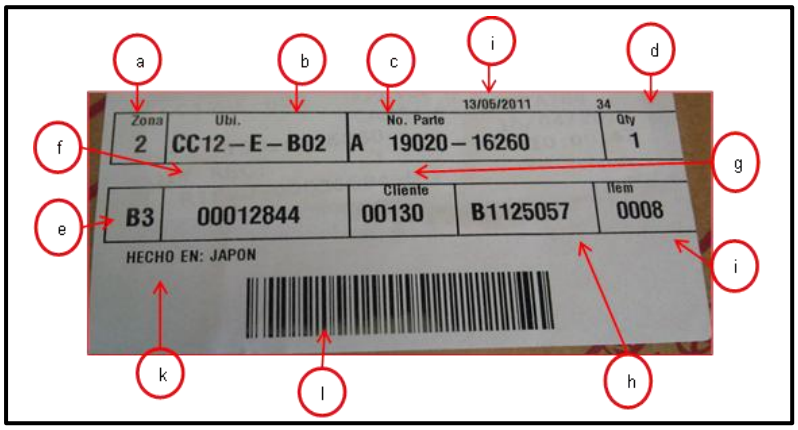


Figure 8 Picking label.

An estimate of the amount of picking labels used in the dispatch operation can be done using the information from the operation of one day. The amount of items is less than the amount of picking labels necessary to pick them. This is because some items might be asked several times during the day.

In the table 7 is shown the amount of items that were billed during a working day (e.g., 3 of May of 2011) with the percentage that each zone represented from the amount of items dispatched (Alvarez, 2011).

Zone	Items	%
1	1522	40,95%
2	959	25,80%
F	461	12,40%
6	407	10,95%
B	112	3,01%
H	67	1,80%
C	60	1,61%
9	46	1,24%
4	30	0,81%
3	23	0,62%
I	10	0,27%
E	9	0,24%
5	8	0,22%
8	3	0,08%
Total	**3717**	**100,00%**

Table 7 Amount of items in the dispatch operation of the 3 of May of 2011.

Table 8 shows the information about the costs of the dispatch operation (in US$) regarding the production of picking labels and main administrative materials to dispatch; also the rest of the costs of materials that are used in the dispatch operation combined as one (Alvarez, 2011). The materials included in this list are:

- The bills, which have 2 copies; one for the warehouse's accounting and one for the dealer's accounting.
- The dispatch guides that are a document printed to Aerocav for them to have the information about how many boxes have to be sent to each dealer.
- The picking labels that are the special papers used during all the operation of the warehouse for the picking, classification and checking of the items.
- The picking notes that are documents printed together with the bills for the operators to check the spare parts that they are putting inside each box.
- The thermic tape, which is the ink used in the printers of the picking labels.
- Other costs, which are the rest of the material costs for the dispatch operation, mainly boxes and tape for the packing of the spare parts.

Description	Bills	Dispatch guides	Picking labels	Picking notes	Thermic tape	Other costs
Qty. Consumed monthly	2.180,47	1.674,42	6.976,74	3.837,21	5	
Cost by unit	0,46	0,21	0,09	0,20	76,74	
Total cost monthly	2.169,56	760,19	1.318,60	1.680,70	383,72	37.396,99

Table 8 Costs of the materials for the dispatch operation in TDV warehouse.

CHAPTER IV

DATA ANALYSIS

4.1 Dispatch operation in the warehouse

4.1.1 Toyota de Venezuela C.A. (TDV)

4.1.1.1 Picking

In this process the key aspect is that the operator has to go to the right location, take the right item and take the correct amount. In the process applied currently, the operator must visually confirm the location to be sure that he is in the right place. Then, he must take one spare part and compare it part number with the one in the picking label. After, he must take the amount of spare parts that was required by the dealer and compare all the part numbers to be sure that they are all the same.

The errors here come from the facts that sometimes in one location it may appear a misplaced spare part with a part number and a shape similar to the one that is being picked, and this is wrongly picked as the spare part that was ordered.

Also, sometimes the operator does not pick all the spare parts that were asked by the dealer. In this situation the warehouse's administration creates a "credit note". This is an administrative document that allows the warehouse to give back the dealer's money of that spare part that was already billed.

This procedure does not add value to the operation, is only an administrative procedure that increase the costs in labor and in documents. This situation must be considered when improving the picking process to eliminate it, with the objective of reduce costs and to improve the usage of time by the warehouse operators.

With these ideas the new process must:

- Create a more effective system to compare the part number of the spare parts with the one in the picking label.
- Create a more efficient system to store the amount that is being picked by the operator.
- Change the process to eliminate the "credit notes".
- Store all the information possible about the procedure.

4.1.1.2 Classification

The classification process is mainly a buffer to distribute what has been picked, to the operators that will be in charge of checking and packing the spare parts. This process is mainly based on checking the dealer code number to put the spare parts in front of the right checker. Since this

point of view this process does not require many changes, mainly because it is an intermediate process.

But, this process has a quality advantage when the operator must compare the spare parts' number with the one in the picking label to be sure that they are the same. Considering this, the improvement of this process might be useful if, after improving the picking and checking process, there are still a considerable amount of errors passing from one to the other. Also, it might require changes to adapt to the new processes that will be applied. With this in mind, for a new classification process must be considered:

- Compare the spare parts' number with the one of the picking label.
- Check the amount and compare all the spare parts' number to be sure that are all the same.
- Compare the dealer's code number in the picking label with the one of the location where he will put the spare parts to be checked and packed.

4.1.1.3 Checking and packing

The checking and packing process is the most critical in the dispatch operation of the warehouse, because is the one in which all possible errors made during the picking and classification processes can be detected and avoid arrive them to the dealer. If the errors are not detected the dealer will have shortages in it material parts.

That will affect the image of the company, will make the warehouse and the dealer to waste time solving these problems and, more important, will affect the final clients by increasing the time that they need to wait for the parts.

The main errors that are committed in this process are that the operator checks a part number but he is actually sending a spare part with another part number, also the operator may check certain amount of the item but he is sending a different amount, and finally he might check an item to the dealer he is packing but that item was not supposed to be sent to the dealer.

All these errors might happen because there are similar part numbers, by the fact that the dealers have similar code numbers or by simple confusion of the operator in charge. In base on this the improvements that must be done to the process must include:

- A more effective method to compare the spare parts' number with the one of the picking label.
- A more efficient method to compare the amounts between what is being packed and what was billed to the dealer.
- The possibility of comparing if the items that are being packed are the ones billed.
- To detect any error in the part number, amount or dealer of the items that are being sent.

4.1.2 Toyota Caetano Portugal (TCP)

4.1.2.1 Picking

The advantages of the method used by TCP are mainly in the use of the scanner as main tool to make the picking process, reducing the influence of the operator in the performance of the process. They use the scanner to compare the part number of the item with the one in the “work assignment”. In case of any mistakes the scanner sounds an alarm to the operator and shows a message in the screen to notify the mistake.

These measures reduce the influence of the operator in the task of comparing the part numbers, thus reducing the errors when reading the part number. After this, the operator scans all the spare parts necessary to complete the order of that item, giving a sonic and in the screen notification in case of a mistake. This method allows keep a clear count of the spare parts picked reducing the possibility of mixing with a spare part from another item.

Also, TCP has two interesting procedures that are worth to evaluate: the first is that they use few picking labels. The picking labels are mainly a tool for internal use of the warehouse that allows them to have a tracking of what item they are picking, who is picking it and for whom they are picking it. But outside the warehouse these labels do not have any use, so after they are used during the warehouse operation they are discarded.

The idea applied in TCP is that they do not print a picking label for every item, they have that information in the system and the scanner only reaches for it when the operator scans the barcode of the work assignment. This reduces the costs in the special paper that is needed for the picking labels and they reduce time during the picking order’s preparation and during the picking process itself.

The second procedure TCP has is what they name as “transferring” a spare part from the location to the box where they are picking the spare parts. This procedure is interesting because it allows track the spare parts from the location to the dealer, keeping with this a record that allows analyze in what stage of the process the errors are made.

4.1.2.2 Check/sort

In the warehouse of TCP they make the picking process according to the geographical areas in that they send spare parts. After the spare parts are picked they check and pack the items following this same scheme. As a standard, they only make one shipment at the end of the day, which allows them to have a process that does not require reduce too much the picking sizes and the amount of dealers that each operator packs.

With this in mind, in their system they make the classification and the packing at the same time, using plastic boxes for all the packing. With this method they reduce the possibility of having a

lost item between processes. Also, this methodology reduces the amount of persons that interact with each spare part, reducing the possibility of errors.

The advantage in this process is that when they check the spare parts they also scan the box in that they are packing it, registering the box and the spare parts that are going to be sent. This register allows a total track of the movements of the spare parts, allowing the administration to know what has already been packed and what they are still missing to complete the shipment.

Also, these registers allow make all the administrative documents that will be necessary to complete the operation, like bills and the information about what the dealer is receiving from the warehouse.

4.2 Key errors indicators (KEI)

There is some important aspect to take in account in the collection of information from the dealers. The dealers are separated entities from the TDV warehouse and, even they must have a combined strategy, each dealer works in base on their objectives. That is why the information given by the dealers only includes those items that they decide to report as errors.

Some of the errors they will not inform back because financially they represent an advantage, such as getting more parts than those paid if they have the space to store those spare parts. In base on that, even if the level of some errors can be seen low it is necessary to consider that the effect over the warehouse is higher than the one showed because there is some level of errors that is not being informed by the dealers.

In the beginning of the analysis of the problem it is necessary to see if there is any clear relationship between the errors committed in the warehouse and several aspects of the operation. This analysis will allow see which are the general aspects of the operation that need to be taken in consideration with the objective of controlling the errors, and allow make better predictions of the possible errors level and establish better goal levels.

The main aspects that could affect the errors are the warehouse monthly's volume of sales, the amount of operators available, the number of working days and the hours worked by these operators by day. To simplify the analysis and make more clear the possible relationship between the errors and the aspects that will be considered for the evaluation, the aspects that will be analyzed are the monthly volume of sales and the amount of working hours available in the warehouse for month.

The amount of working hours available in the warehouse for month can be explained as the total amount of hours that all the operators worked in the dispatch operation during the month. These two aspects contain the two major considerations of the operations: the orders by the dealers and the labor available.

For the analysis we will use time series plot to see the tendencies between the months for the aspects in consideration. Even if these tendencies do not give us an exact relationship between the

variable we will be able to see in a general idea how the two aspects mentioned will affect the errors in question. First we have the plot for mispicking errors in TDV with the data from table 1.

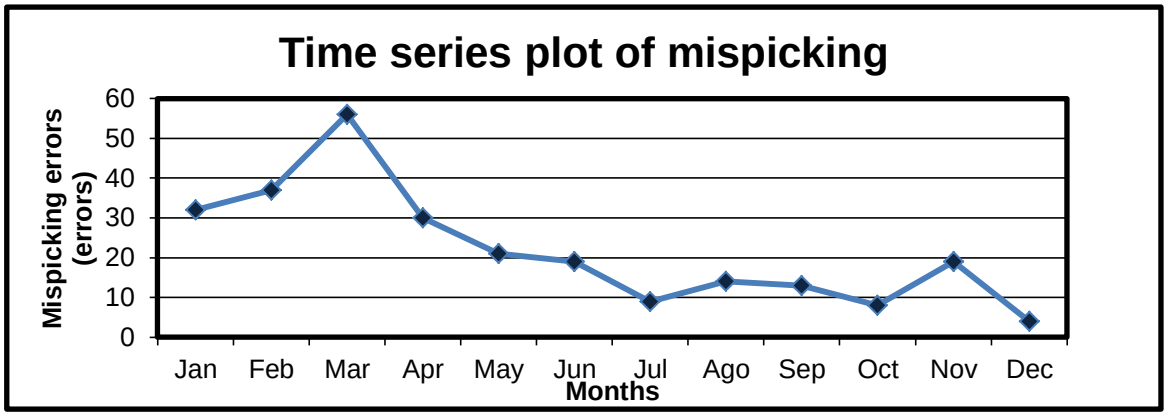


Figure 9 Time series plot of mispicking in the year 2010 in TDV.

In the figure 9 we can see that at the beginning of the year the errors were increasing, starting in 32 and reaching to a top of 56, but after March started a dropping to 9 errors in July. After this the errors had two high pikes in August and in November, and in December a minimum of 4 errors. We can see here that the performance of the warehouse show a clear improvement of the process, showing a general diminishing from 32 errors in January to a lowest 4 errors in December.

We can also see that between the months of February and March there is a high growth of the errors that does not correspond with any other period of the year. Also in the next period of March and April we can see the highest diminishing of errors. From these two aspects we can conclude that there was some situation between these three months that requires investigation.

Next we have the time series plot from the warehouse denials from the year 2010 in TDV, made with the information from the table 2.

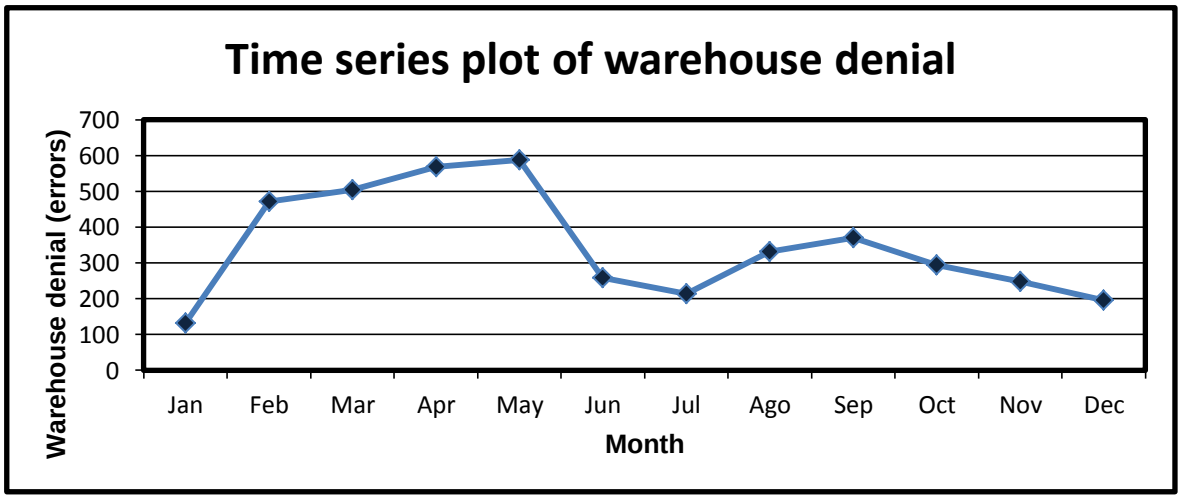


Figure 10 Time series plot of warehouse denial in the year 2010 in TDV.

In the figure 10 we can see that at the beginning of the year there were high problems with finding the items in the warehouse where, from January to May, the errors raised from 131 to 588.

After this we can see a high drop on the errors up to a first minimum of 213 in July. After, we have another pike up in September up to 370, and finally the errors start falling to a minimum of 195 errors in December.

One important aspect to consider when analyzing these errors is that the same mistake might produce errors several times. This is because the same item might be misplaced for certain period of time, and when asked by several dealers are constantly giving this error. What we can in general see is that there is not any improvement in the process during the year.

In figures 11 and 12 we will present the time series plots of volume of sales (figure 11) and available hours (figure 12) in the month. The data for these graphics was obtained from the table 5, where the available hours by month was calculated from the formula:

$$Available\ hours\ by\ month = Operators * Worked\ days * Hours\ by\ man \quad (4)$$

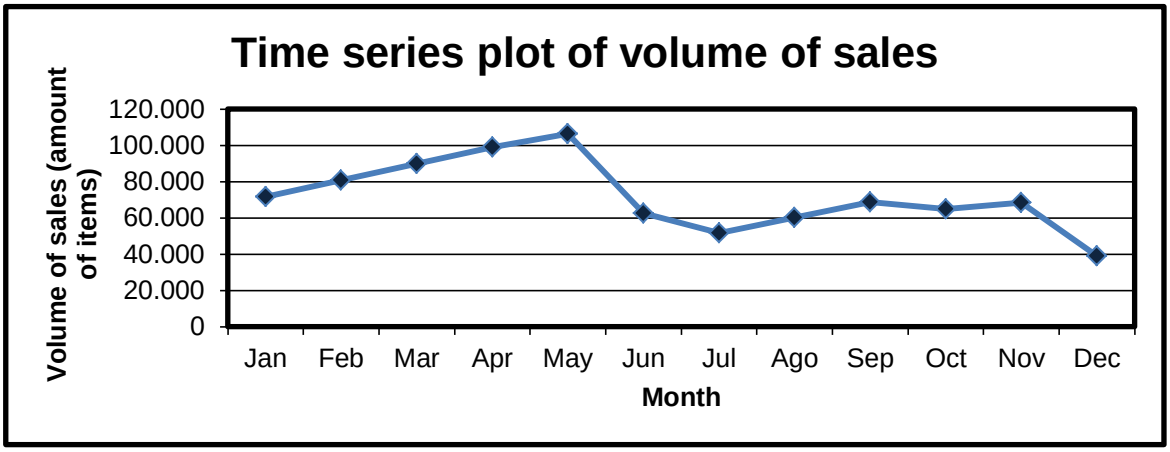


Figure 11 Time series plot of volume of sales.

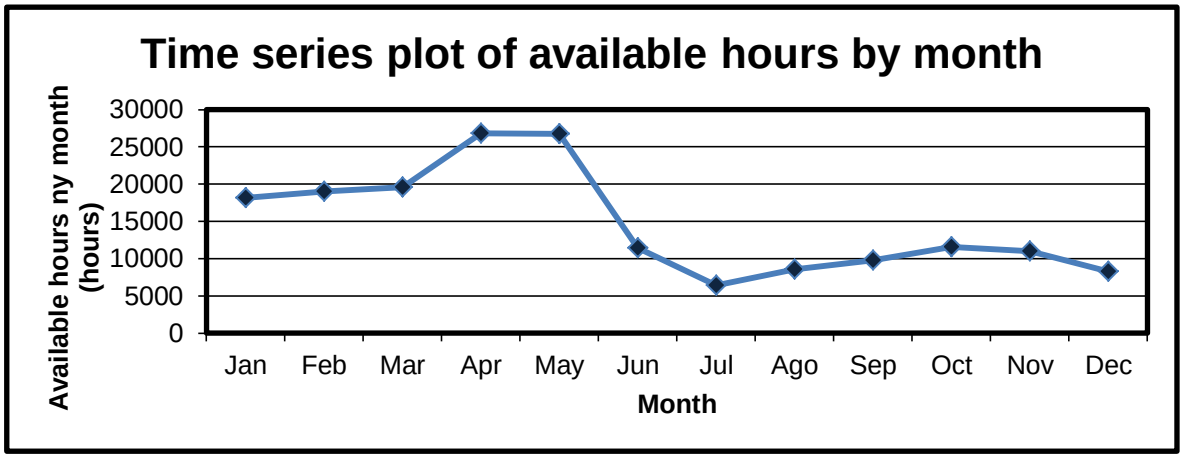


Figure 12 Time series plot of available hours by month.

When we compare the shape of the graphic from volume of sales (figure 11) with both graphics for errors we can see a big amount of similarities. In the three graphics we can see a growth

at the beginning of the year, pointing to that with higher volume of sales the numbers of errors increase.

This is quite evident if we compare the graph from warehouse denial (figure 10) with the one of volume of sales (figure 11), when we can see that both graphs have the same tendencies in almost all the intervals except for October-November. When we analyze the specific data for each period we can see that in October there were the highest numbers of errors for the zone 9 (security spare parts), representing in this month almost the 50% of the errors in this area.

Also, we can see that the graph of available hours by month (figure 12) is similar with the one from the warehouse denial, in almost all the intervals except from April-May and September-October. This suggests that the more time available in the month for processing the spare parts, the higher is the amount of warehouse denial committed by the operators.

At first, this seems contradictory, because increasing the time should help the operation and not harm it. But this tendency can also be seen as that the increase of working time and volume of sales increase the possibilities of errors. This makes sense if there is a higher amount of material to check and control and more operators manipulating them, increasing the possibility of each operator making a mistake

In the case of the mispicking graph (figure 9) and the sales' volume we can see more differences, between March and May and between August and September. In the first period, March-May, we can see that this is the period with the highest hours available of work. This may explain why the errors in this period are reduced while the volume increases. A high increase in the amount of hours worked reduced the amount of work that each operator had to do, reducing the necessary time and giving more time at the operators to check each item.

In the case of August-September the reduction in the amount of errors in mispicking is quite low. If we see the data from sales' volume and available hours for that period we can see that the change is very similar in both graphs. This suggests that is possible that the similarity in these aspects is creating stability in the process what allowed the operators reduce the mispicking errors made.

In the case of mispicking against the hours we can see differences in the periods of March-May and August-November. From this, it seems that there is not clear relation between the amount of time for the operation and the errors committed. This does not seem right, even more when we see that some of the differences between the volume and the mispicking can be explained with the amount of available hours in the month.

To explain this we need to remember that the dealers do not give feedback about all the errors that are made, so here we may have a lack of information that is hiding the tendencies suggested in the previous analysis. This makes sense because in those periods which the mispicking errors and the volume of sales do not follow the same patterns, the amount of available of hours by month are a good explanation for these differences.

In conclusion, we can say that the volume of sales is an important factor affecting the amount of errors committed in the TDV warehouse. Its tight control will help to have a better control over the

amount of errors. Also, some of the data seems to indicate that with a longer time in the operation the mispicking errors might be reduced.

In the case of the warehouse denial it seems that the extra hours produced higher errors. This may happen because more peoples are involved with the handling of the spare parts. We would also consider that some of the mispicking errors may create warehouse denials, so focusing the analysis and the new processes in controlling this aspect may help reduce the amount of both types of errors.

4.2.1 Mispicking

The data provided by TDV was transformed in a "parts per million" base (ppm), so it could be easily compared with the data from TCP. In the table 9 we present the volume of sales during the year 2010 from TDV that was used to calculate the errors per million. This table was done using the information form the table 1.

Volume of sales	**863.193**	
Types of errors	**Total cases**	**PPM**
Less quantity	55	64
Excess quantity	21	24
Wrong part number	149	173
Missing item	36	42
Other	1	1

Table 9 Mispicking information from TDV in the year 2010.

When we make a Pareto chart using this data (in ppm), about the mispicking errors in TDV, we obtain the one showed in figure 13.

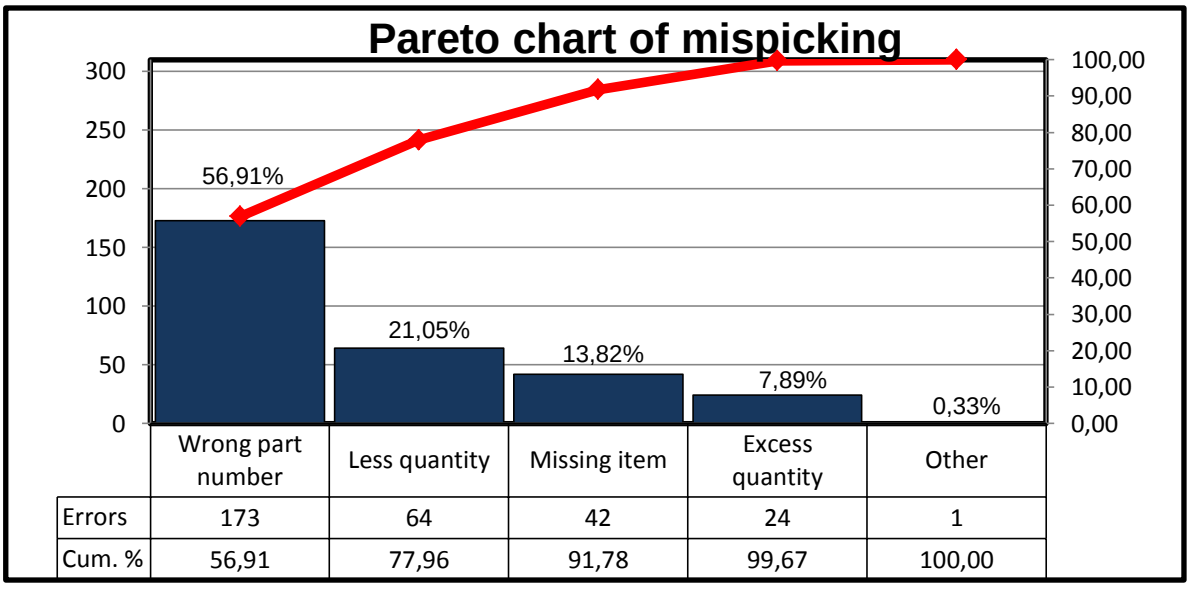


Figure 13 Pareto chart from the mispicking information of TDV in the year 2010.

This chart shows that the main error committed by the operators is when a wrong spare part is picked and sent to the dealer. With this error representing almost a 60% of the errors committed, it must be considered as the main aspect to be evaluated at the moment of studying and improving the picking and checking processes.

Also, observing the other causes is possible to see that 29% of the errors are related with quantity issues. With this in mind, in our approach to analyze the processes must also take in account the need of keeping a better control of the quantities to reduce these problems. This also shows that the "wrong part number" and the "less quantity" are the main issues that concern the dealers when they are sending the error information to TDV warehouse.

When we see these same aspects in the TCP warehouse (table 10), also expressed in "parts per million" we see some clear differences between the proportion of errors between this warehouse and TDV warehouse (table 11).

Types of errors	PPM
Less amount	57
Excess amount	6
Wrong part number	16
Missing item	3
Other	0

Table 10 Mispicking information from TCP in the year 2010.

Types of errors	TDV	TCP
Less quantity	64	**57**
Excess quantity	24	6
Wrong part number	173	16
Missing item	42	3
Other	1	0

Table 11 Comparison between mispicking information from TCP ad TDV in the year 2010.

We can clearly see how the errors are substantially lower in almost every aspect than the ones from TDV. There is only one case in that both amounts of errors are almost the same and that is in the less quantity errors. This may come because in the picking process from TCP they use a box to pick the items, mixing them up, which may cause that some spare part get confused with another one and the operator does not notice it. In the Pareto chart (figure 14) we will also get something quite different compared with TDV.

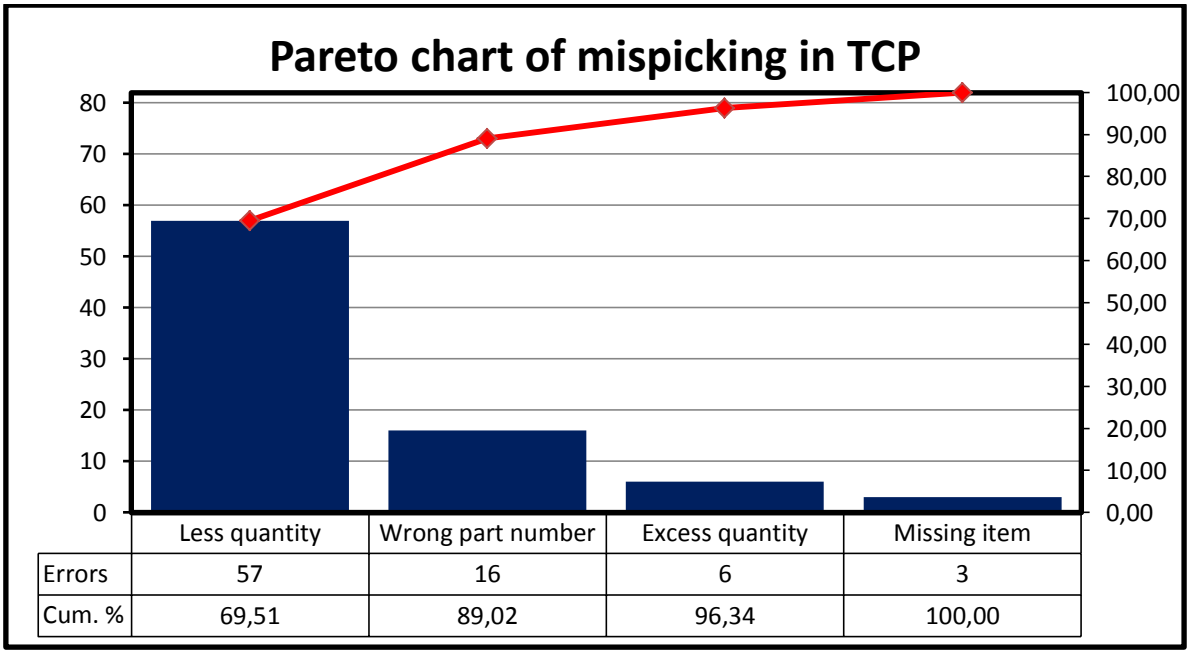


Figure 14 Pareto chart from the mispicking information of TCP in the year 2010.

In this chart we can see that the main problem is sending less quantity than the one that was checked. This error represents a high percentage of the errors in this warehouse. Comparing this chart with the one from TDV we can see how the error "wrong part number" is clearly smaller, which shows that the methods used in the TCP warehouse should reduce the errors in the TDV warehouse.

When considered the possible mistakes that are being made by the operators, which may cause the mispicking errors, we get the figure 15 of the cause-effect diagram below.

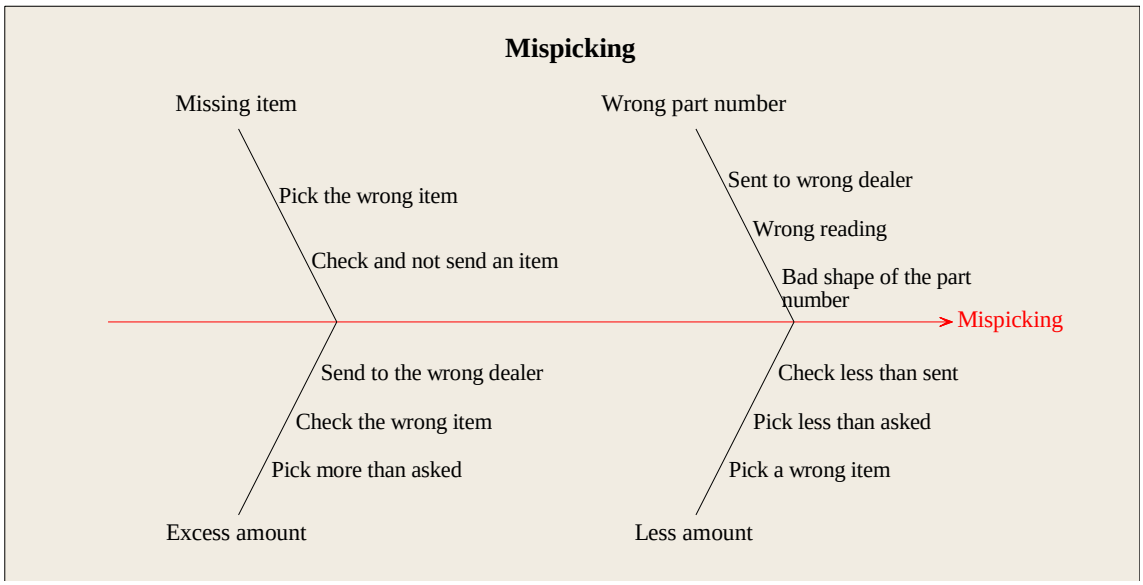


Figure 15 Cause-effect diagram of the mispicking errors in TDV.

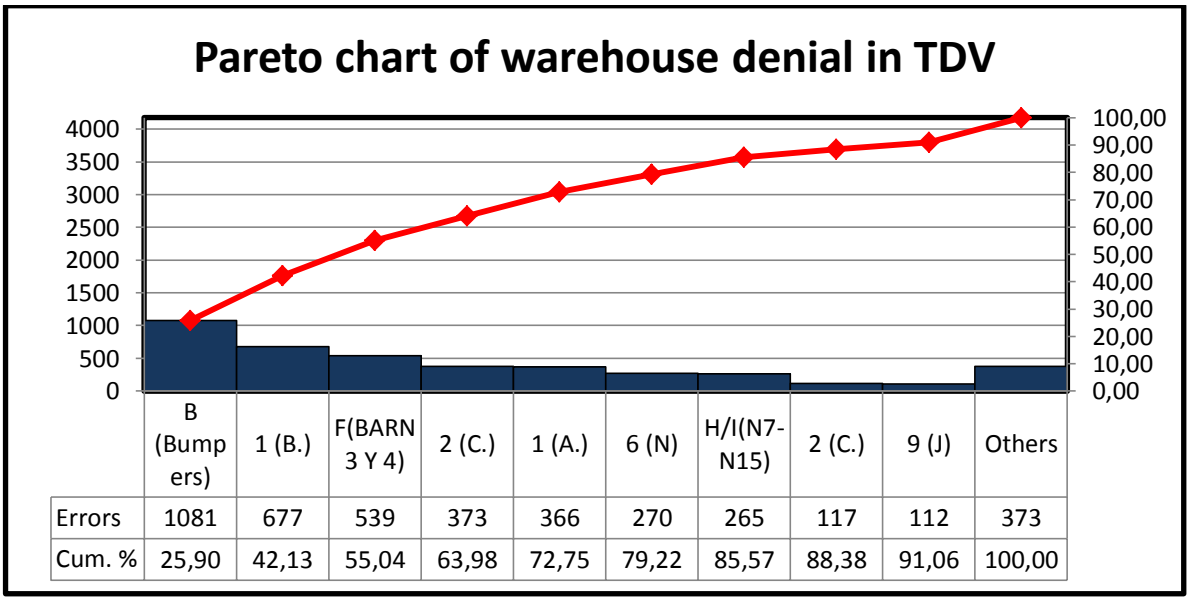
Between the possible causes for this error the mistakes are mainly committed by the operators in charge of the picking and checking process. There is a pattern in the causes, where the confusion of part numbers is the bigger problem seen by this error indicator.

The tracking of the right amount of spare parts is also an important factor contributing for this type of error. In conclusion, to control and reduce this error the best way is to assure the matching of the part numbers and have a better track of the amounts picked during all the processes.

4.2.2 Warehouse denial

The data provided by TDV about the warehouse denial is divided by warehouse zones. This is because this type of error may be based in different aspects that are hard to define, like errors in the allocation process, in the dispatch operation or in the claiming process.

So the best way to evaluate this variable is analyzing it according to the zone, and to see the different measures that can be applied to reduce this error in each one of them. With this in mind we made a Pareto chart (figure 16) to analyze which zones of the warehouse need higher attention in the development of the new processes. The data for the Pareto chart comes from the table 2.



	B (Bumpers)	1 (B.)	F(BARN 3 Y 4)	2 (C.)	1 (A.)	6 (N)	H/I(N7-N15)	2 (C.)	9 (J)	Others
Errors	1081	677	539	373	366	270	265	117	112	373
Cum. %	25,90	42,13	55,04	63,98	72,75	79,22	85,57	88,38	91,06	100,00

Figure 16 Pareto chart from Warehouse denial in TDV.

It is possible to see that the Zone B (Bumpers) is the one that represents higher errors so it is recommendable to analyze it, but the errors are highly distributed between several areas. This may suggest that the problem is not the zones but the general processes used to allocate and pick items.

In base that there is not a clear picture we can analyze which are the possible reasons that can produce this error, to try to find which common points might be the ones higher affecting this error. This is important because this error represents the situation in which the warehouse cannot supply the dealers, so reducing it will increase the service rate of the warehouse and the client satisfaction, allowing the dealers to give the earliest possible the spare parts to the clients. According to this, we can see in the cause-effect diagram (figure 17) the possible reasons that might produce this error.

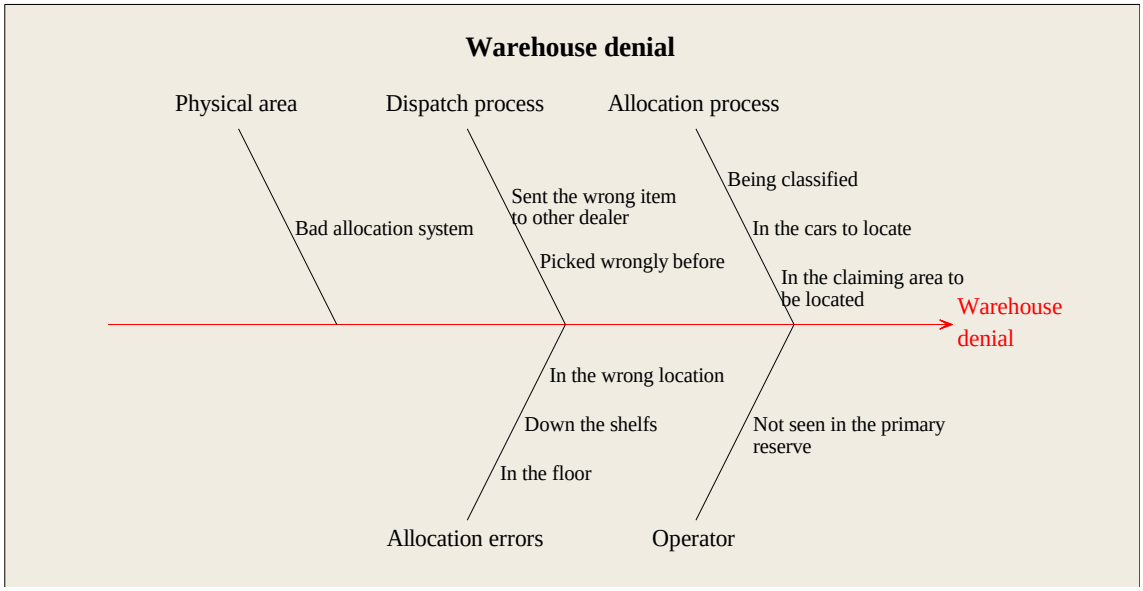


Figure 17 Cause-effect diagram of warehouse denial in TDV.

As we can see, the main reasons that affect this error are related with the process of allocation and with errors on the dispatch process according to the confusion between part numbers. According to this we can conclude that, to reduce this error we need to establish a way to reduce the allocation errors in the warehouse and to avoid the confusion between part numbers.

In base of the information from the table 4 we create a chart (figure 18) to compare the percentage of warehouse denial errors against the percentage of items billed by zone. The objective of this is to analyze if there is any relationship between the amount of errors and the amount of items in different zones of the warehouse. The graph presented is the comparison between the amount of items and the warehouse denial of the warehouse for the year 2010.

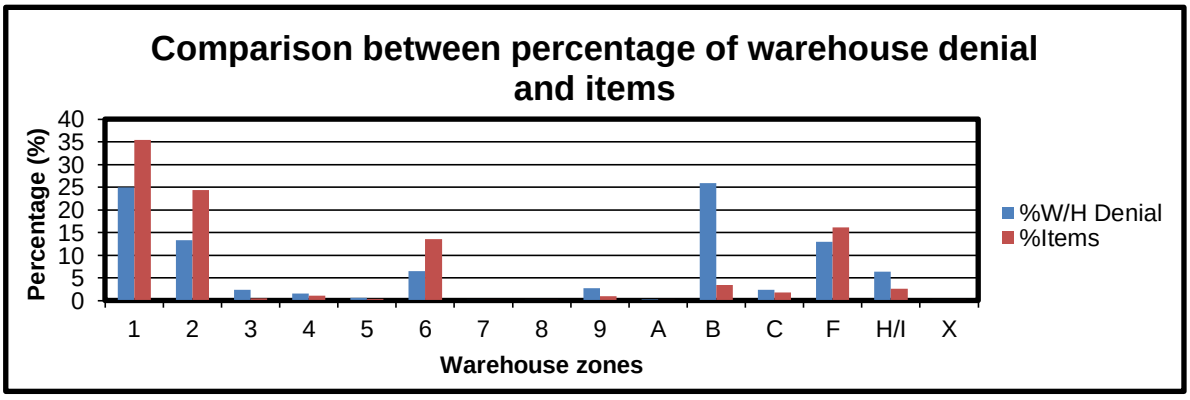


Figure 18 Comparison between Warehouse denial and Items by zone in TDV.

In this graphic we can see that there is not a clear relationship between the percentage of items and the percentage of warehouse denials in each zone. But we can see that in several cases a high percentage of items are also representing a high percentage of warehouse denials. Also, in the zone A (Accessories) we can see that TDV has a problem of high warehouse denials: this is one of the areas with more errors but with less items stored.

4.3 Productivity

To evaluate the productivity we made a time series plot with the information of the table 5, to try to find the patterns during the year of the productivity. This is shown in figure 19.

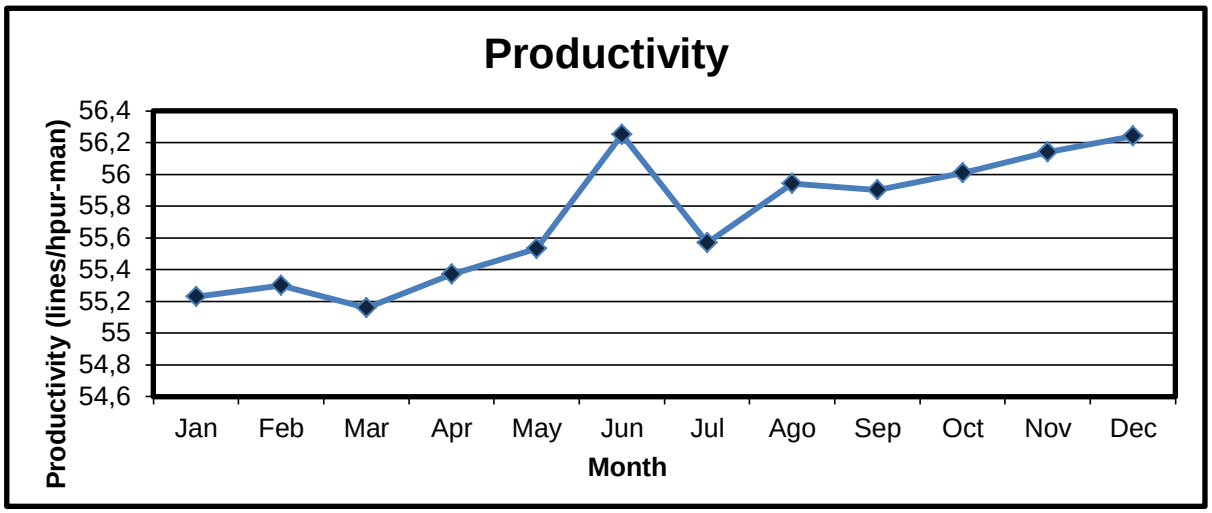


Figure 19 Time series plot for the productivity of TDV in 2010.

In the figure 19 we can see that the productivity is constantly rising during the year showing that the performance of the operators is slowly, but constantly, improving. We have two interesting periods: those are May-June and June-July.

The reason for the pike in June is that from May to June the sales' volume is reduced nearly by 40% (from 106.205 to 62.424), the number of operators in almost 30% (from 14 to 10) and the available hours by operator nearly by 40% (from 1.912,65 to 1.146,70). The productivity increased because the decrease in the amount of items was lower than the one in the amount of operators and the decrease in the available hours by operator.

For the second period we have a decrease in the sales' volume in near a 15% (from 62.424 to 51.660), one in the amount of operators in about 30% (from 10 to 7) and one in the available hours by man by nearly 20% (from 1.146,70 to 920,50). This causes a situation opposite to the one explained before: the decrease of the volume was lower than the one of available hours and of operators and this results in a decrease in the productivity.

For this analysis and from the formula (see section 3.3) we can see that this indicator is not representing the real situation of the operation of the warehouse, because it represents the amount of items that are processed by hour by an operator, considering as if all the processes were only one. We know that this is not real; the dispatch operation is divided in 4 main processes each one with a certain operation time and certain delays that are not being considered in the formula. Also, the hours used in this formula are theoretical, they do not consider the real use of hours that the operation has.

With this, the new method to measure the productivity of the warehouse should consider the different processes that are performed in the operation (not the operation as one process) and the real time that the operators use to perform each process.

CHAPTER V

PROPOSAL SOLUTIONS FOR IMPROVEMENT OF TDV'S SHIPMENT OPERATION IN THE WAREHOUSE

5.1 New processes

The concept for the new dispatch operation is to automate it with the use of the scanner, looking improve the dealer serving's quality, reduce the internal processing time and reduce costs.

With this in mind, the best concept should be to implement as much as possible the use of the scanner in all the dispatch's processes, looking to reduce the amount of paper material that is used in the warehouse and reduce the processing time.

But, the application of these measures cannot be done all at once, because the operators need a time for adjusting for each new process. Considering this, the application of the new processes will be done in two stages: the first one mainly considering the improvement of quality and the second one for reducing costs.

For the new processes will be used as main tool a barcode scanner, being this the tool applied by the warehouse of TCP to improve their method and reduce the errors by reading the wrong part number.

The first stage will include the application of the scanner in the processes of picking and checking in the warehouse with the main objective of reducing the errors. The second one will have as objective the reduction of costs reducing at the minimum the amount of picking labels that are used during the operation.

At the end of second stage the operation of dispatch in the warehouse will be fully automated. This will be done reducing the amount of picking labels necessary for the processes using the scanner to substitute them, presenting in the screen the necessary information for the processes.

5.1.1 First stage

As it was said, the first stage includes the improvement of the picking and checking processes. This must be done considering the final operation that will be used in the warehouse. With this in mind the picking process must include, since the beginning, the establishment of barcodes for all the trolleys. This will allow the use of the procedure of transferring the spare parts from the allocation to the trolleys, to perform a better tracking of their movement through the warehouse. This register will also allow start analyzing the errors in the system and solve any problem before any extra process be applied.

At the same time that this process is applied, it will be applied the improvements in the checking process. This is done because the improvements in the picking process will not directly affect the improvements in the checking process. This is possible, firstly, because the classification process will be used as a checking between both, and when the operators should report any error detected.

For this the best idea should be to give all the operators any control sheet that will let them record these errors, so the necessary measures can be taken. The second reason why these processes should be applied at the same time is that both have a digital record that should be constantly compared by the system and will allow the identification of any failure and to monitor the improvements in the processes applied.

5.1.1.1 Picking

For the picking process the use of the scanner has the following objectives:

- To compare the spare part's number with the picking label.
- To have a more accurate counting of the spare parts those are being picked.
- To allow a simple tracking, to know who collected a specific spare part, when and where it was transferred to.
- To prepare the information that will be used to classify and check the spare parts.
- To help to eliminate the "credit note" procedure from the picking operation.

To reach these objectives the process will use the scanner to read the part numbers to compare them in a better way, reducing the influence of the operator in the process. Also, at the beginning of the process the operator must introduce his own information in the scanner (through a password or a barcode) so the device identifies who is operating it and can make a precise record of his development. Following this line, the operator will have to scan the barcode of the trolley he is going to use for picking spare parts so the system knows in which trolley the spare parts are after the picking.

In what refers to the quantity there are two possible ideas. The first one is that, when doing the picking process, all the spare parts that are being picked must be read in the scanner to assure that all of them are the same and the scanner will make the count of how many are being picked by the operator. The problem in this method is that in some cases it might result in a long process when it is required to scan a lot of spare parts' numbers, even if this process is the ideal one.

The second method would try to make a middle point between the first one presented, that is highly secure but it might increase the processing time for each order, and the productivity of the process: the method would be that always that the amount of spare parts to be picked is lower than 10 they should be all scanned, but if the amount to pick is 10 or more the operator must compare all the spare part numbers visually and introduce the amount directly on the scanner.

This alternative must highly reduce the amount of errors in the quantity and in sending a spare part in the place of another one in the orders of less than 10 spare parts. But over 9 spare parts the scanner will only work as a comparison for the first spare part, the rest will be counted manually. This method doesn't improve the quality at the top but according to the orders made in March and April of 2010 only around 3% of what is being ordered has amounts of 10 or more spare parts, so this shouldn't affect too much the operation.

The most important change that will be done in this process will be the one that will allow eliminate the "credit notes" from the picking process. The idea here is that the billing process be done not in base on what the dealer order, but in base on what the operator will be able to pick.

In the scanner, after the operator scans the part number, he will see the quantity he needs to pick and he will start picking it. If he does not find enough spare parts he will have to press in the scanner that the picking of that spare part is over and then he will have to confirm it. This process will allow at the warehouse administration have, in real time, the information about what is being picked up for each dealer, and use this as basis to prepare the bill that will be sent to the dealer. This will eliminate the need of "credit notes" to cover when the operator doesn't find the spare parts.

The process for picking in the warehouse (see details in annex 3) will be:

- The operator scans his barcode (or introduce his password) with the scanner.
- To take the picking cycle and a trolley.
- To scan the barcode of the trolley.
- To scan the barcode of the picking label (in the screen will appear the part number, the location and the required amount).
- To go to the indicated location.
- To confirm the location visually.
- To check that the location is the right one.
- To scan the barcode of the required item.
- To register the amount.
- To confirm the amount.
- To put the picking label in the spare parts.
- To put the spare parts in the trolley.
- To follow the process until pick all the items from the list.
- When the process is done take the trolley to the classification area.

At the end of this process, the system will receive the information of the items that were picked by the operator, and then they will be organized according to the dealer that will be sent. Any

information about an error will be stored so the management can evaluate the performance of each operator and analyze what improvements the processes will need to reduce the errors.

5.1.1.2 Packing

The objectives for the new packing process are:

- To compare precisely the part number in the spare part with the picking label.
- To have an accurate counting of the spare parts packed for each dealer.
- To allow a simple tracking procedure to know who packed what for a specific dealer.
- To prepare the information that will be sent to the dealer with the items packed for him.

For this process it will be used a system in which the operator will fill the box based on a list of items that he will receive in the scanner. This information will be about the amount of items and spare parts that will be necessary to pack. This information will come from the record of what each operator picked during the route and it will be updated each time that an operator finishes his cycle.

To assure that the checking of a dealer be closed in the right time, all the spare parts picked must be packed. For this, the scanner will have a signal that will tell the operator when all the spare parts from his dealer have been picked. This will be done by comparing the part numbers that have already been picked by the operators, with the part numbers of the orders from the dealers.

The new process is as follows (see details in annex 4):

- The operator scans his identification's barcode in the scanner.
- To scan the barcode of the dealer with the scanner (the scanner will show the amount of items and of spare parts that will be packed by the dealer).
- To record the box that is going to be sent in the scanner as "box 2".
- To take the spare part to be checked.
- To scan the barcode of the picking label (the scanner will show the amount of spare parts to check).
- To record the amount of items.
- To put the spare parts in the box.
- To repeat this process until all the spare parts are packed for the client.
- Press "close box".
- Press "End checking".

At the end of this process, the system will receive the information of the spare parts that were packed by the operator, and then the bill will be printed based on what was checked. Also, it will be produce a record based on in which box each item is and the dealer. Any error in the checking

process will be stored so the management can evaluate the performance of each operator and analyze what improvements the processes will need to reduce the errors.

This change will also eliminate by complete the necessity of the “picking notes”, producing a cost reduction of 1.680,70 US$ monthly (table 8).

5.1.2 Second stage

The second stage of the automation of the warehouse will start only after the previous two processes are fully functioning and the comparison between what is picked and what is checked for each dealer is showing that the process is working properly. This stage has as main objective to reduce the costs of the operation of the warehouse and to reduce the processing time of the orders. Until now, there are two main tools that are used in the dispatch operation:

- The barcode scanner for the process of picking and checking the spare parts that will be sent.
- The picking labels which contain the information about what is going to be picked and to which dealer will be sent.

The picking labels are, specifically, an internal tool that contains the information about the items. But these labels have a cost for the operation that may be substantially reduced with the use of the scanner. With the new processes there will be an appreciable reduction in the amount of picking labels necessary.

Based on the tables 7 and 8, and as an example, in the mezzanine zone we can have a daily reduction from around 1500 picking labels to a steady 103 labels. This number represents the addition of the amounts of dealers that are attended per route. This reduction will represent the elimination of more than 90% of the picking labels used in this zone.

For the rest of the warehouse the change is different. For each working cycle there is a maximum of 40 items to be picked (for productivity and time reasons). Based on table 7 we can estimate the picking label necessaries: for zone 2 in 3 picking labels per route and in the zones F and 6 in 2 picking labels per route. In the rest of the areas the picking labels necessary will vary according to the orders, so we will estimate 1 picking label for each route in each one of these zones.

Having this considered, in the worst case scenario we will have, in the rest of the warehouse, 107 picking labels. In the day we analyzed we had around 2200 picking labels, representing a reduction of nearly 95% of the picking labels used. So, in average, we have a reduction above 90% in the amount of picking labels. Considering the data for the table 8 we will have a monthly cost reduction of around 1.300,00 US$ (reducing 90% the picking labels and only buying one thermic tape by month). At this we have to add the complete elimination of the picking notes, which have a monthly cost of 1.680,70 US$, giving a total reduction of around 3.000,00 US$ monthly to the dispatch operation.

5.1.2.1 Classification

For this process it will be needed the barcode scanner because of the elimination of most of the picking labels. The idea will be, during this process, to confirm that the spare parts that are being sent and that the amount that was picked are the same that was recorded by the operator. The objectives for the new classification process are:

- To adapt to the changes that are being applied in the warehouse.
- To check what was picked to ensure that there are no errors in the process.
- To allocate properly the spare parts in the shelf for the corresponding dealer.

This process will work in the opposite way than the packing process. In the packing process we have a box that needs to be filled until a certain amount of items be reached. In the classification process we will have the opposite, the operator will scan the barcode of the trolley and he will receive the information of what it contains.

With this information he will keep scanning the barcode of each item and introducing the amount, after which he will receive the code number of the dealer who he needs to transfer the items. Then he will take them to the dealer's allocation and will scan it barcode making the transfer of the spare part from the trolley to the shelf. This will ensure that all the spare parts are transferred to the shelves thus reducing the possibility of quantity errors.

Based on this, the classification process (see details in annex 5) is:

- The operator scans his barcode with the scanner.
- To take the trolley that will be classified.
- To scan the barcode of the trolley.
- To take the item to classify.
- To scan the barcode of the picking label.
- To check the amount of the item and introduce it in the scanner.
- To take the spare parts to the dealer‘s location.
- To scan the barcode of the dealer.
- To put the spare parts with the picking label pointing at the checker.
- To proceed the process until classify all the trolley.
- Press “end classification”

5.1.3 Scanner

5.1.3.1 Screen of the scanner

For the use of the scanner in these processes there are applications that need to be created for the scanner (for more details see annex 6). For the correct implementation of the operation will be suggested that each process should have a main screen describing the main information necessary.

For the case of the picking process the information the screen should contain is:

- Franchise of the item.
- Part number of the item.
- Location of the item.
- Dealer where the item will be sent.
- Route in that the item will be sent.

Below this, the screen of the scanner will have an area where it will be recorded the part number that is being picked, the amount that needs to be picked and the amount that is being picked. After the picking of each item is completed, the screen of the scanner will go to a screen that will ask for the part number of the item. Those screens are showed below, in figure 20 and in figure 21.

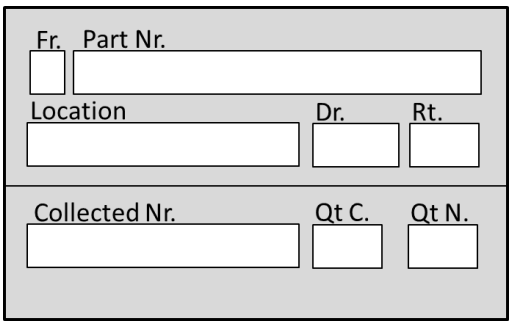


Figure 20 Screen for the picking process.

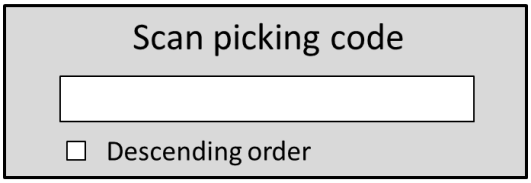


Figure 21 Screen for the beginning of the picking process.

In the case of the classification process the screens are showed in the figure 22 and figure 23. The first screen will be to scan the barcode of the trolley. Then the scanner will show a second screen, where the information showed will be: the franchise, the part number of the item that is being classified, the quantity that was picked, and the dealer which will be sent and the route in that will be sent. After this, it will be a section for the information that the operator will input: the dealer number and the quantity he is classifying.

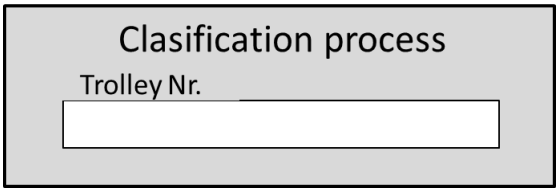


Figure 22 Screen for the beginning of the classification process.

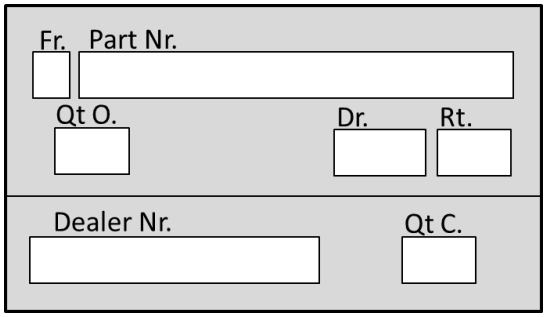


Figure 23 Screen for the classification process.

In the case of the checking process the screens are showed in figures 24 and 25. The first screen will ask for the dealer's code number; after this the main screen of the process will include:

- Franchise of the item.
- Part number of the picking label.
- The dealer which will be sent.
- The route in that the item will be sent.
- The amount of spare parts already checked and of spare parts that need to be checked.

After this, the screen will have a section where the operator will input the following information: the part number of the item checked, the quantity picked and the quantity checked.

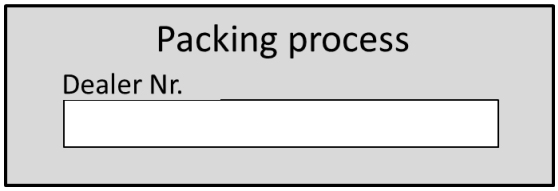


Figure 24 Screen for the beginning of the checking process.

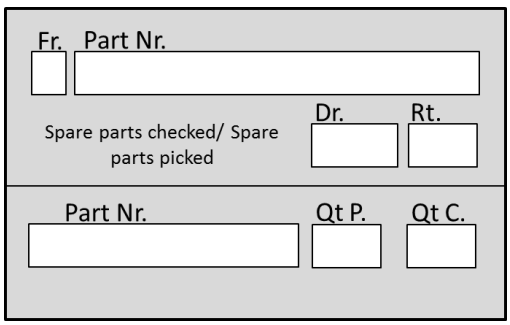


Figure 25 Screen for the checking process.

5.1.3.2 Errors with the scanner

The operators may commit errors when they are using the scanner (see details in annex 6). If these errors are not noticed they will go to the next level of the operation affecting it. The best way to prevent this from passing is giving the employee a warning when errors are committed.

The safer method would be to combine a sound alarm, which would alert the operator that something is not going as planned, and a message in the screen that will require confirmation from the operator.

This will ensure that the operators see that an error was committed and will force him to take an action to correct it.

5.2 Key errors indicators (KEI)

5.2.1 Service level

With the new system where the bill is created based on what the operators pick and check, the measurement of the service level will not be clear in the bills as in the present process. But in reality the warehouse is not giving the full orders to the dealers because they are not sending everything that the dealers asked.

It is still necessary to have the track of the difference between what the dealers receive and what they ordered. Now, for taking this statistic the best method would be to compare the order of the dealer with the list that was sent to the dealers regarding the spare parts that were packed and sent. This data will be used for the new evaluation process with the scanner explained after.

5.2.2 Data collection system

In the current process of the warehouse of TDV when an item is not found or not enough spare parts are found, there is an operator that receives this information and will try to complete the order.

With the new system, where the billing process is done based on what is firstly picked by the operators, the idea of looking for the spare parts during the route is not important anymore. But the concept of looking for the missing spare parts would be really useful for the improvement of the allocation process in the warehouse. With this in mind is recommended to change the work made by this operator to look for the missing items, collect the data about the location that the item was found and put it in it right location.

The operator in charge of looking for the spare parts will have a list with all the items he has to find. He will have to collect the information about what is the relative position of the item compared with its original position, the amount that was found and who located that item.

The possible locations would be:

A. - Reserve.

B. - The locations at the side of the correct one.

C. - Correct shelf, but in the wrong row.

D. - Correct shelf but wrong column.

E. - Wrong shelf.

F. - Wrong hall.

G. - Found in the floor.

H. - Waiting to be allocated.

I. - Other places.

In the system, all these options must be easily modifiable to adjust it to changes required by the data. In the moment that the operator locates an item he will have to mark it in the list he has with the lost items. In the case that the location of the item was marked as “others” he should write where it was found. The reason “J” will not be measure by this person but it should be in the system and it would be “sent to a dealer”.

The list will be made each day. This was decided based on that the data about warehouse denial showed that in average in 2010 there were 18 w/h denials per day. This is an amount high enough to be considered because this is not the only work that this operator has during his daily routine, so he will have to dedicate sometime to this process but will not occupy all his day, and if any accumulation of part numbers occur it will not become an excessive number.

Also, it must be add to this an elimination process form the list, that when after certain time that the item is not found in the warehouse, it will be eliminated from the list and will be reduced from the stock in system doing a count of the spare parts in the location. This time should be no more than a week, because the existence of this amount in the system is an error that will affect the operation and at the end the service level of the warehouse. If the item is, after this period, sent back by any dealer, reason “I”, this amount will be add to the stock in the system and the piece reallocated in it correct place.

The list that will be used for this process will be organized according to the date in which this item was declared as “not found”, so it can be found as soon as possible. This will reduce the effect that this missing part will have in the service given to the dealers. This list will include:

- The part number of the item that needs to be found.
- The date in that this item was declared as “not found”.
- The amount that could not be picked for the order that was sent by the dealer.
- The location where the item should be found.
- The amount that should be found in the right location.

- How much is in process for being allocated for each item.

The procedure that this operator would follow for this task would be:

- The operator will check in the list the items that need to be found.
- He will check in the proper location, in the reserve and in the surroundings of the location for this spare part, including the same location in several halls and shelves, also in the floor and in reserve.
- When he finds the item he will scan it.
- He will take the spare parts to the proper location.
- He will count the spare parts.
- He will write in the screen the location (referred with the letters already mentioned), the amount that was found and, if possible, who was the operator that misallocated that spare part.
- He will scan the proper location and will relocate the item in it proper place.
- He will count all the spare parts to see if they match with what should be in the location.
- If he finds more in the location that it should be he will check if the difference represents what is in process of being allocated but is not yet in the system.
- He will follow with the next item of the list.

With the information taken with the scanner, it will be done a new indicator called "misallocation". This indicator will be measured by zone of the warehouse, being considered all the reasons for errors except for the reason "J", which represents a dispatch problem. With this, the formula will be:

$$Misallocating\ from\ zone_i = \frac{Errors\ commited\ allocating\ in\ zone\ i}{Items\ in\ zone\ i} * 1.000.000 \quad (4)$$

Where:

$$Errors\ commited\ allocating\ in\ area\ i = A + G + H + I + 2(B + C + D + E + F) \quad (5)$$

In this formula the letters represent the possible places to find the pieces. Variables B to F are multiplied by two, because those errors represent the spare part in another allocation; this problem is affecting two items, the one where are missing and the one where is extra, so these problems should be considered as two errors at the same time. This formula will allow the analysis of which zones have

bigger problems and require more attention in the evaluation and improvement of the layout and processes in the warehouse.

For completing this statistic will be also calculated an indicator that will be called missending, which will represent the evaluation of reason “J”; it formula will be:

$$Missending\ in\ zone\ i = \frac{Errors\ type\ "J"\ in\ zone\ i}{Items\ in\ zone\ i} * 1.000.000 \quad (6)$$

The combination of this statistic with the misallocation should give as result the “warehouse denial” errors, because here are represented all the possible causes that can produce the absence of the spare part when the operator is looking for it, being the formula:

$$Warehouse\ denial = Missending + Misallocating \quad (7)$$

5.3 Planning for the application of the changes

The application of the changes that are being recommended needs to be done in a systematic way. If the changes are tried to be applied all together that might create failures in the processes and problems in the operation. As it was said before the process is divided in two stages, one mainly in charged in the improvement of quality, while the other one is mainly for reducing costs in the process. At this we have to add the implementation of the data collection system that can be done simultaneously to the dispatch changes. The estimated time is of 53 weeks. A more detailed explanation of the plan can be seen in annex 7.

5.3.1 First stage

Having this in mind the application of the first stage will start by the checking process. This will be done because this process can be easily adapted to work with the present operation in the warehouse. This will allow evaluate the performance of the checking process without the effects of the new picking process and make the necessary adjustments.

For the implementation will be first trained two or three operators to use them as test subjects for the process, they will perform the checking process with the scanner and with the picking notes during two weeks, working with low volume dealers. This will allow compare the process between the manual and automated system, with which the management will be able to certify if the scanner is working properly and if it is storing the correct data.

After this is done there will be a week in which the management will compare the picking notes with the data stored by the scanner, and the operators will give the feedbacks to make the necessary adjustments to the process. With this adjustments will start the training of the rest of the operators of

the warehouse. They will be tested during one week, where the operator will use both the picking notes and the scanner for the process in low volume dealer.

After all the operators are approved the picking notes will be eliminated and will be given a time for the fully adapt of the operators to this process before implementing more changes.

With the checking process fully applied we can pass for the next step: the picking process. After the system department finishes the development of the checking process they should pass to create this system.

For its implementation, the first part will be to train one or two workers from the mezzanine zone. This zone is chosen because it does not pass through the classification and checking processes, so any error will be only from the picking process and this will improve the evaluation of the process.

These operators will test this system around one or two weeks in this zone, comparing the information about what was picked against the order and against the picking notes to evaluate the performance of the process. In this first stage the bills will still be printed at the beginning of the operation.

After this period, the results will be evaluated and in base on this and in the feedback given by the operators the necessary improvements for the system will be done. With these improvements the training will be given to all the operators and they will be tested by comparing the picking information with the checking information and the dealers' orders. After all the operators are trained the process will be fully established starting the print of the bills after the checking process based on what was picked and checked.

5.3.2 Data collection system

With these two processes the first stage of the application of the system ends. The most advisable at this point is to give some time for the operators to adapt to the new processes in the operation of the warehouse. During this time, it should be applied the data collection system, using it to reduce the errors in allocation and start the improvement of the warehouse since the entrance of the items.

It application is simple, because after the system department finishes the program it must be trained the operator that will be applying this system. He should have constant feedback with the system's department so the system is constantly improved. This operator has to make the daily job of looking for the pieces and weekly he should give a report to the supervisor about the amount of errors he found in the different categories to discuss improvements to the warehouse.

5.3.3 Second stage

After the data collection system is applied, the next stage is the cost reduction. In this stage we will apply the classification process in the warehouse. The process for the application of this system is similar to the one of the checking system. Will be realized the train of two or three operators so they start the tests. They will test the system comparing the dealers' numbers from the picking labels with the ones from the scanner. After this test is done, the process is improved, the train is fully done and the operators are tested. Finally, the picking labels are reduced and the process is fully applied.

5.4 Productivity

The use of the barcode scanner brings the possibility of collecting a large amount of data that was not possible in the past.

This data can be used for evaluating the performance of the operators and the warehouse in general. With this in mind, it is possible to apply a procedure to calculate the productivity's indicator for each operator and from the warehouse in general, considering the different processes that are being done during the operation.

This is possible because each scanner will record the time that each operator takes for performing a certain cycle operation (picking cycle, classification of a trolley or packing a dealer). This information allows the system to make a precise calculation of the amount of work that each operator needs to perform a certain operation. With this idea the new productivity indicators, by operator and for the entire warehouse will be:

- Picking productivity, representing the amount of items that are being picked by hour.
- Classification productivity, representing the amount of items that are being classified by hour.
- Sending productivity, representing the amount of items that are being checked and packed by hour.
- General productivity of the warehouse, representing the amount of items that the warehouse process, taking into consideration the differences between the zones and the processes.

Each process will be classified in 4 types of productivities: productivity by operator by zone, productivity by operator, productivity by zone and productivity of the process. The reason for this is that each measure will help to make more specific analysis to the process and the operators. Even if they are not all always presented they must be easily calculated when they become necessary.

All this productivity measures should be calculated daily, weekly and monthly to try to find patterns in the data. For each time frame that the following formulas be used, it is better to use it like it

is expressed in instead of an average, because this will allow keep an easier track of the different components that conforms it. Also, all this indicators will have as units:

$$[\frac{items}{hour * man}]$$

5.4.1 Picking productivity

The picking productivity should be estimated by zone of the warehouse, because each zone has different types of items and so the processing time for each zone will be different. The first productivity will be calculated according to each operator. The productivity in the picking process for each operator in each zone (PPOZ) will be calculated as:

$$PPOZ = \frac{Items\ picked\ in\ the\ zone\ by\ the\ operator}{Time\ used\ for\ picking\ those\ items} \quad (8)$$

If the operator picks in different zones of the warehouse the system must be able to calculate the proportion of time that this operator worked in each zone, and the picking productivity by operator (PPO) will be:

$$PPO = \sum_{i=1}^{n} (PPOZ_i) * \left(\frac{IPZ_i}{TPI}\right) \quad (9)$$

Where:

n = number of zones in which the operator picked items.

$PPOZ_i$ = the productivity of the operator in each zone of the warehouse.

IPZ_i = number of items the operator picked by zone.

TPI = the total number of items that the operator picked.

To calculate the productivity by zone (PPZ) of the warehouse the best method is to sum all the items that were processed in that zone, and divided by the time that were necessary by the operators to process them.

$$PPZ = \frac{\sum_{i=1}^{m} Items\ picked\ in\ the\ zone\ by\ operator\ i}{\sum_{i=1}^{m} Time\ used\ to\ pick\ items\ in\ the\ zone\ by\ operator\ i} \quad (10)$$

This formula gives the average time that would be necessary to process the items from this zone. This means that, if the PPOZ of an operator is higher than the PPZ he is working above the average from that zone and if it is lower he is working below the average. The best approach with this statistic will be to try to keep all operators close to the average.

For the productivity in the picking process of the warehouse (PPW), it will be used the productivity by zone (PPZ) and a factor given by the ratio between the amount of items that were picked in that area, and the items that were picked in the warehouse. The formula is:

$$PPW = \sum_{i=1}^{n} (PPZ_i) * \left(\frac{IPZ_i}{TPI}\right) \quad (11)$$

This formula expresses the productivity of the picking process in the warehouse, taking in consideration the differences between the processing times in the different areas. This formula will also allow estimate in a precise way the average time in picking.

For the mezzanine zone the picking productivity will represent the general productivity for this zone, because the classification and checking are not done there.

5.4.2 Classification productivity

For the classification process productivity measurement, it will be followed the same scheme as for the picking process, given that each trolley that is classified brings items only from one zone. The formula for the classification productivity by operator by zone (CPOZ) is:

$$CPOZ = \frac{Items\ classified\ from\ the\ zone\ by\ the\ operator}{Time\ used\ to\ classify\ those\ items} \quad (12)$$

For the classification from different zones by the formula is:

$$CPO = \sum_{i=1}^{n} (CPOZ_i) * \left(\frac{ICZ_i}{TCI}\right) \quad (13)$$

Where:

CPO = Classification productivity by operator.

n = the number of zones from which the operator classified items.

$CPOZ_i$ = the productivity of the operator classifying from each zone of the warehouse.

ICZ_i = the number items the operator classified by zone.

TCI = the number of items that the operator classified.

This indicator will be the most realistic, because it will represent the classification productivity by operator, and will effectively represents the capacity of the operator over this process. To calculate the productivity by zone (CPZ) of the warehouse the method will be to sum all the items that were processed from that zone, and divided by the time that was necessary by the operators to process it.

$$CPZ = \frac{\sum_{i=1}^{m} Items\ classified\ from\ the\ zone\ by\ operator\ i}{\sum_{i=1}^{m} Time\ used\ to\ classify\ items\ from\ the\ zone\ by\ operator\ i} \quad (14)$$

Finally, this indicator will allow calculate the productivity for the classification process in the warehouse (CPW), which will be:

$$CPW = \sum_{i=1}^{n} (CPZ_i) * \left(\frac{ICZ_i}{TCI}\right) \quad (15)$$

5.4.3 Checking and packing productivity

For this process, the collection of the data becomes a little more complicated than in the picking and classification processes. In this process the items already come mixed, to take the data for each zone will be necessary to store the time for the checking of each item and separate it according to the zone. With this condition for this process will be applied the four indicators that were already applied to the previous processes.

Sending productivity by operator by zone (SPOZ):

$$SPOZ = \frac{Items\ packed\ from\ the\ zone\ by\ the\ operator}{Time\ used\ to\ pack\ those\ items} \quad (16)$$

Sending productivity by operator (SPO):

$$SPO = \sum_{i=1}^{n} (SPOZ_i) * \left(\frac{ISZ_i}{TSI}\right) \quad (17)$$

Where:

n = the number of zones from which the operator packed items.

$SPOZ_i$ = the productivity of the operator packing from each zone of the warehouse.

ISZ_i = the number of items the operator packed by zone.

TSI = the number of items that the operator packed.

This indicator will be the most realistic, because it will represent the checking and packing productivity by operator, and will effectively represents the capacity of the operator over this process.

Sending productivity by zone (SPZ):

$$SPZ = \frac{\sum_{i=1}^{m} Items\ packed\ from\ the\ zone\ by\ operator\ i}{\sum_{i=1}^{m} Time\ used\ to\ pack\ items\ from\ the\ zone\ by\ operator\ i} \quad (18)$$

Sending productivity of the warehouse (SPW):

$$SPW = \sum_{i=1}^{n} (SPZ_i) * \left(\frac{ISZ_i}{TSI}\right) \quad (19)$$

5.4.4 General productivity of the warehouse

For the general productivity of the warehouse it will be considered two main ways. The first one is for benchmarking purpose. That is, in the warehouse management, the handling productivity of the warehouse (HPW). This indicator represents the amount of spare parts that the warehouse moves during it operation, which represents the size of the processing of items inside the warehouse by hour. The formula for this indicator is:

$$HPW = \frac{IP + IC + IS}{TP + TC + TS} \quad (20)$$

Where:

IP = Items picked in the warehouse.

IC = Items classified in the warehouse.

IS = Items packed and sent in the warehouse.

TP = Time used for picking the items.

TC = Time used for classifying the items.

TS = Time used for packing and sending the items.

It is possible to see that this formula represents the proportion between the amount of material processed and the time used to process it. Mainly to establish an idea about the size of the operation that is done in the warehouse.

The second method that will be considered for the calculation of the warehouse productivity will have as objective allow the management have an idea about how much time will be necessary to make the items pass through all the warehouse process. As in the previous cases this productivity will be evaluated according to the zone of the warehouse. It is called general productivity by zone (GPZ) and the formula will be:

$$GPZ_i = \frac{1}{\left(\frac{1}{PPZ_i}\right) + \left(\frac{1}{CPZ_i}\right) + \left(\frac{1}{SPZ_i}\right)} \quad (21)$$

The formula can be explained by an example: if we have three processes that are consecutives where their productivities are p, c and s, which express [pieces/hours]. If we want to know how much time will take to process a certain amount m of pieces the calculation would be:

$$Time\ to\ process = \left(\frac{m}{p}\right) + \left(\frac{m}{c}\right) + \left(\frac{m}{s}\right) \quad (22)$$

This formula expresses the amount of time required for completely process those pieces, now that we have the time and the amount we can calculate the general productivity as:

$$Productivity = \frac{m}{Time\ to\ process} \quad (23)$$

Where, simplifying the “m” we will get:

$$Productivity = \frac{1}{\frac{1}{p} + \frac{1}{c} + \frac{1}{s}} \quad (24)$$

The formula can be simplified if the amount of items picked, classified and checked is the same, which can happen if the process occurs without “missing items” errors. In this case, the formula would be:

$$GPZ_i = \frac{items\ processed\ in\ the\ zone\ i}{time\ to\ process\ from\ the\ zone\ i} \quad (25)$$

Where:

$$\begin{aligned} &Time\ to\ process\ from\ the\ zone\ i \\ &= time\ to\ pick\ in\ zone\ i + time\ to\ clasify\ from\ zone\ i \\ &+ time\ to\ pack\ from\ zone\ i \end{aligned} \quad (26)$$

Finally, we can calculate the productivity of the whole operation as:

$$GPW = \frac{1}{\left(\frac{1}{PPW}\right) + \left(\frac{1}{CPW}\right) + \left(\frac{1}{SPW}\right)} \quad (27)$$

This formula will represent an average between the processing times for each area of the warehouse. This will allow compare it with the different zones and know which type of item are the slowest to process during the operation.

5.5 Picking label

The picking label will have a series of changes during the application of the new processes. In the first stage we have as main aspect to consider the movement of the bills' printing from the beginning of the operation to the end. This has its effects in the picking labels.

Mainly, all the information related to the bill cannot appear in the picking label because it does not exist. Eliminating the information about the bills should be the only change done during this stage of the process; this is because the application of the next stage will be in a short period of time after the establishment of this new system, so any change in the picking label in this moment will not last long.

After the second stage of the process is established, it is possible to make more changes of the picking labels. The new picking labels will not require much information. The main control will be done through the barcode that will be in the middle of the picking label. Besides this, the rest of the information that will be present in the picking label will change according to the zone of the warehouse where it will be used.

In mezzanine, the picking labels will include the date, the route that is being worked and the dealer which the items are being sent. For the rest of the warehouse it will include the date, the route,

the zone of the warehouse to pick and which cycle of all the ones that are planned for that zone in that route is being picked. It is possible to see images of the picking labels in figures 26 and 27.

Figure 26 Image of the picking label for the mezzanine area.

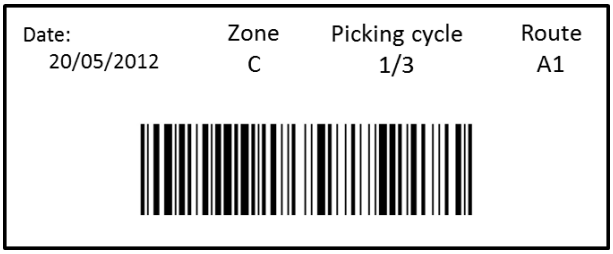


Figure 27 Image of the picking label for the rest of the warehouse.

5.6 Quality policies

With the changes that will be applied in the operation in TDV warehouse, a new and large amount of information will be available, that can help the warehouse to improve their processes. However, alone, this information will not help the warehouse improve their quality and productivity.

To develop better systems it is necessary to establish clear standards in the methods that will be used for the evaluation of the data. These methods should be adapted according to the different information that is being stored. But also, these new methods must be adapted to the philosophy that the company is already following.

If the change is too drastic it will be hard for the management to adapt to the new changes. With this in mind, the new methods will be evaluated according to each one of the new indicators that are being used and following the Kaizen quality policy used by the warehouse. But first, it is a recommendable idea to establish general policies that will be followed through all the evaluations.

5.6.1 General indicators vs. specific indicators

General indicators, like mispicking in the warehouse or productivity of the dispatch process, are really useful for the analysis of the performance of the warehouse as a whole operation. This gives the bases for establishing the new objectives for the development and improvement of the system and the processes applied on it.

But they are not adequate to solve specific problems, because they do not differentiate between factors like the operators, the zone or the moment where the errors were made. Without this differentiation is not possible to identify the cause that is producing the errors.

In base on this, it is recommendable to set a secondary group for each indicator, which will allow the evaluation in a more precise way. These variables should be the evaluation of errors according to each operator; to each zone of the warehouse and the time in that the process is done.

Even all these variables do not need to be all the time expressed should be really easy to calculate them. For these evaluations should be better start first analyzing by zone, then by time and finally by operator. The reason for this is that is more probable the errors come from a failure in the processes than from the operators.

With this, is highly recommendable that the system stores all the information that is possible to calculate the different specific indicators that the management decides to use to improve their operation. This information should be kept at least for six months; this will allow an easy evaluation of the aspect that they decide over time. After this period, it should be stored that information that was considered relevant for the improvement of the operation.

5.6.2 Errors per million

The quality measures used at the present time at TDV are based on the concept of “errors by every 10.000 lines”. Up to the moment this base has worked properly. But as we could see in the different data that was presented during this work, this base line is starting to be insufficient to evaluate the process.

The warehouse from TCP works in a base line of “errors every 1.000.000 lines” or ppm. This method has the advantage that allows represent easier the errors that are being made during the operation. Also, it has a psychological advantage because it makes the management and supervisors try to get the best value possible looking for the improvement of the quality of the processes that are being made in the warehouse.

In base on this psychological advantage and in the necessity of establishing a better base line to evaluate the quality of the warehouse, all the error evaluation measures will be establish in a base of “parts per million” or ppm.

5.6.3 Control sheets

In some processes it might be necessary information that is not possible to get from the scanner. For example, it might pass any error from the picking process to the classification that the operator locates before scanning the spare part. In these cases it might be recommendable not to use the scanner to pick this but to use a control sheet that allows store the necessary information. The

objective of this is to establish in the operators the culture of looking the errors and to try to solve them.

5.6.4 Checking times

All these evaluations need to be studied by the management of the warehouse. But, they cannot be checked all days, there must exist a period of time before each one of this indicators be studied. If they are studied to soon it might not be able to identify changes in the error, but if they are tested too late the errors might highly affect the operation.

Also, the management of the warehouse has different levels; not everybody has to be involved in every step of the process. According to this the advice would be to establish weekly checks of the information. Having 4 main variables it would be really unproductive analyze them all the same day. The best method is to have an order, checking one each week but comparing the rest with the previous weeks just to be sure that have not been any important change in them that is not expected.

After this, monthly should be given a report to the higher management to keep them informed with the changes, and involve them in those cases that are becoming hard to solve or that require high level decisions.

5.6.5 Training

For the proper application of a more complete quality system it is necessary to teach the operators the proper methods that need to apply. In base on this, it is necessary to prepare the different trainings that will be necessary to apply for the new processes work properly. Besides, in the moment of evaluate the performance of the operators, if it is necessary any reinforcement of the processes there must be always open the possibility of retrain the operator so the basic concepts might be fortified.

5.6.6 Documentation

One of the basis for every process to be able to be followed and improved it is to have the proper information organized in the best way possible. Having all the necessary information will allow the management to analyze all the different aspects they decide to consider as fast as possible.

This information should be kept for a period of at least 6 months. This is a period long enough to find certain tendencies in the processes that might be necessary to solve. After this period it is still highly recommendable to store the basic information that allows make comparisons in the future, for example some of the indicators already calculated, in the way that the amount of data stored is reduced but that the information keeps.

5.6.7 Graphics

A good method to analyze the indicators is graphics. The graphics allow, rapidly, to see tendencies and to see which the key aspects to consider are. There are two main graphics that will allow evaluate the indicators. To evaluate the indicators over time the best idea is a line chart that shows the tendencies that are occurring in the processes.

In the case of analyzing different aspects inside the same indicator (causes for errors, areas of the warehouse) the best graphic that should be used is a Pareto chart. This graphic shows in a clear way the proportion of an aspect inside the whole, allowing find which are the key aspects that are affecting the situation. With this, the graphics must be put in a board so it is seen by all the employees and they participate in the evaluation process.

5.7 Route diagram

With all the changes that are going to be applied in the warehouse there are necessary some adjustments into the route diagram. This is the document that represents the times in the different processes of the dispatch operation for every route that is sent. For this adjustment we need to analyze which processes are having a change that should require a schedule adjustment.

When we see the picking, classification and packing processes is clear that the changes that were done are not affecting the order in that these processes are implemented. It might reduce the time necessary for them, but any change according to this should be evaluated by the warehouse after the new processes are fully functioning. The big change will occur in the processes of printing bills and the printing of picking labels.

After the first stage the bills' printing will pass from the beginning of the process to the end. In this case, after every operator finishes checking a dealer, he will give the order with his scanner to print the bills of the dealer. With this in mind the process for printing the bills should start after the end of the classification process, that is when we can be sure that all the items that were picked for that dealer were moved to the respective place.

In the printing of picking labels the changes refer to the time that will be necessary for this process. With the advance of the changes each time will be necessary less picking labels for the operation, and the time necessary for produce and arrange them will also reduce.

With this, we will have 2 route diagrams during the application of the new processes. The first one will come after the application of the first stage of the changes; this one will include the change in the location of the process of printing the bills (see annex 8). The second one will include the time reduction in the process of printing the picking labels, increasing with this the time to pick items in the process (see annex 9).

CHAPTER VI

RECOMMENDATIONS AND CONCLUSIONS

6.1 Recommendations

During the realization of this work, there were some ideas that were appearing that, for reasons of time and scope of the work, were not included or evaluated during the work. But, they are suggested for future evaluations of the operation of the warehouse with the hope that they help to improve the quality and at final the service level and client's satisfaction.

6.1.1 Consider the elimination of the "reserves"

This aspect was not mentioned during this work but, in some of the zones of the warehouse, like mezzanine, when a spare part does not fit in its location it is putted in the top location of the shelf that is designated as "reserve". This system has been used during a long time in the TDV warehouse, but it has been noticed that this system produces errors when the operator does not look for items in this area.

In the TCP warehouse this system is not used. Instead, they put the spare parts that do not fit in the location, in the location at the side of the main one, with a signal that marks the relation between both.

This method allows for a clear view of all the spare parts from that item and will eventually reduce the warehouse denial errors improving the service level and the client's satisfaction.

6.1.2 "Data collection system"

The "data collection system" has as objective the gathering of data about the inventory states and to allow understand which errors the operators are making. In its initial approach this system is only used to locate those spare parts that are being looked for during the normal operation of the warehouse.

But, the use of this system can be extended to other areas. One of those areas is the inventory's control done each year. Each year the warehouse management counts all the spare parts stored to make adjustments in their systems for the next year, to start with the proper amounts. In this operation large amount of location's errors are found. A good method to improve the data quality to solve the location's problems would be to collect the data that is being generated.

In the case that this be considered too much information, it can be selected those zones that during the year have presented a large amount of warehouse denials so one could evaluate them and try to solve its problems.

This system can also be used during the whole year to evaluate certain zones of the warehouse with the objective of understand why are occurring the errors.

It is recommended to evaluate the zone “B” (Bumpers), and try to find the main reasons that are producing so many errors in this zone. In fact this zone accounted for about a 25% percent of the warehouse denial errors of the warehouse in 2010.

Also, it is important to analyze zone “A” (accessories) because the percentage of warehouse denials is quite high in this zone, compared to the percentage that it represents in the warehouse’s sales.

6.1.3 Plastic boxes

In the new checking and packing process the boxes will be identified with a number. This system will be good with the use of carton boxes but, considering the plans of the warehouse regarding the use of plastics boxes in the operation; it is recommended that this plan should be combined with the application of the new checking process.

Even this is not mandatory for the plastic boxes; a system where each box has a bar code pasted on it to identify it can be applied. This will allow a simpler tracking of the boxes during the operation and will eliminate the chances of any error done by the operator while inputting the data about the identification of the box.

6.1.4 Future improvements

The next improvement that can be done is to eliminate completely the picking labels. To perform the working cycle is only necessary to access specific information. In the case of mezzanine, the operator will introduce the code number of the dealer and the route that is being picked. In the rest of the warehouse the operator will introduce the zone where he has to pick and the system will give him the working cycles of that zone.

This will allow reduce even more the costs of the operation and will also improve the processing time of each working cycle.

6.2 Conclusions

In this work it was analyzed the dispatch's operation of TDV's warehouse with the objective of presenting a proposal for its automation.

The first analysis that was done was about the processes from TDV warehouse. From this analysis it was concluded that the key aspects in this process is the capacity of the operator to compare spare parts' numbers with the information of the picking labels and to count parts.

It was also made an analysis of the errors that are recorded in the operation.

From the analysis of the mispicking errors it was concluded that the main mistakes made by the operators are to compare wrongly the spare parts' numbers with the picking labels and to count the amount of spare parts that are going through the process.

This confirms that the problem in the processes is that, mainly, the processes depend in the capacity of the operators to compare the spare parts' numbers. According to this it was concluded that the new processes should take the comparison from the operators to the scanner.

Also, analyzing the errors' data from TCP warehouse, it was concluded that the use of a barcode scanner, as main tool in the process, can significantly reduce the errors produced by the miss comparison of the spare parts.

From the analysis of the general procedure used in the TDV warehouse it was concluded that there were a group of documents (picking labels, "credit notes" and "picking notes") that could be significantly reduced or eliminated from the operation of the warehouse. This can be done with the use of the barcode scanner. This procedure will produce a reduction in the cost of the operation of the warehouse and will improve the productivity in the process.

Analyzing the data of warehouse denials it was concluded that for it improvement the application of these new processes was not enough. For the resolution of this problem it was proposed a new "data collection system" that will allow to collect and analyze this error in each zone and try to find the best solution for it.

After the processes were developed it was considered their application in the warehouse. It was concluded that applying all of them at the same time would cause inacceptable disturbances or even failures in the operation, so it was proposed that a schedule of the application of the processes that will allow their proper revision and full application.

After, there were considered the quality policies that need to be applied in the operation of the warehouse so the processes can work at it highest potential. It was concluded that for a proper utilization of this system, it is necessary the use of graphic material (charts and plots) that will help the management and the operators analyze the situation, that a proper documentation of the errors would help to improve the operation and that the training of the operators is the best way to attack the errors that appear in the operation.

At the level of the indicators it was defined a new set that will help to better analyze the situation in the warehouse. In the productivity side it was concluded that the current method to calculate the productivity in the warehouse is not correct. The new method will use the time that each scanner is processing spare parts as base to calculate the productivity.

It was concluded that the use of the scanner will give the possibility of collecting a more accurate data about the time spent by each operator to process items and, with this, to create a more accurate system that will give a more realistic value of the productivity of the warehouse.

Finally, we can conclude that the use of a barcode scanner can help to reduce the errors done in TDV warehouse by the operators. Also, the use of this scanner can, significantly, increase the amount of information that is being collected by the warehouse to improve the operation and to have a better analysis of the operation.

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ANNEX

List of annex

Annex 1 - Route diagram

TOYOTA

POST VENTA

RUTAS	CIERRE DE PEDIDO TDV	IMPRESIÓN DE FACTURAS Y PICKING	ASIGNACION DE TRABAJO	RECOLECCION		CLASIFICACION		EMPAQUE		CARGA DE LA MERCANCIA	ITEMS POR RUTA
A1 W1	03:45 DIA ANTERIOR	03:55	04:00	08:10	08:50	08:20	09:00	08:20	09:15	09:20	557
A2 W2	08:30	08:40	08:45	08:50	09:30	09:00	09:40	09:00	09:55	10:00	604
A3 W3	09:10	09:20	09:25	09:30	10:10	09:40	10:20	09:40	10:35	10:40	663
A4 W4	09:50	10:00:00 a.m.	10:05	10:10	10:50	10:20	11:00	10:20	11:15	11:20	631
A5 W5	10:30	10:40	10:45	10:50	11:30	11:00	11:40	11:00	11:55	01:00	616
B1 W6	11:10	11:20	11:25	11:30	01:10	11:40	01:20	11:40	01:35	01:40	643
B2 W7	12:50	01:00	01:10	01:10	01:50	01:20	02:00	01:20	02:15	02:20	670
B3 W8	01:35	01:45	01:50	01:50	02:30	02:00	02:40	02:00	02:56	03:00	664
B4 W9	02:15	02:25	02:30	02:30	03:10	02:40	03:20	02:40	03:35	03:40	626
B5 W10	02:55	03:05	03:10	03:10	03:50	03:20	04:00	03:20	04:15	04:20	440

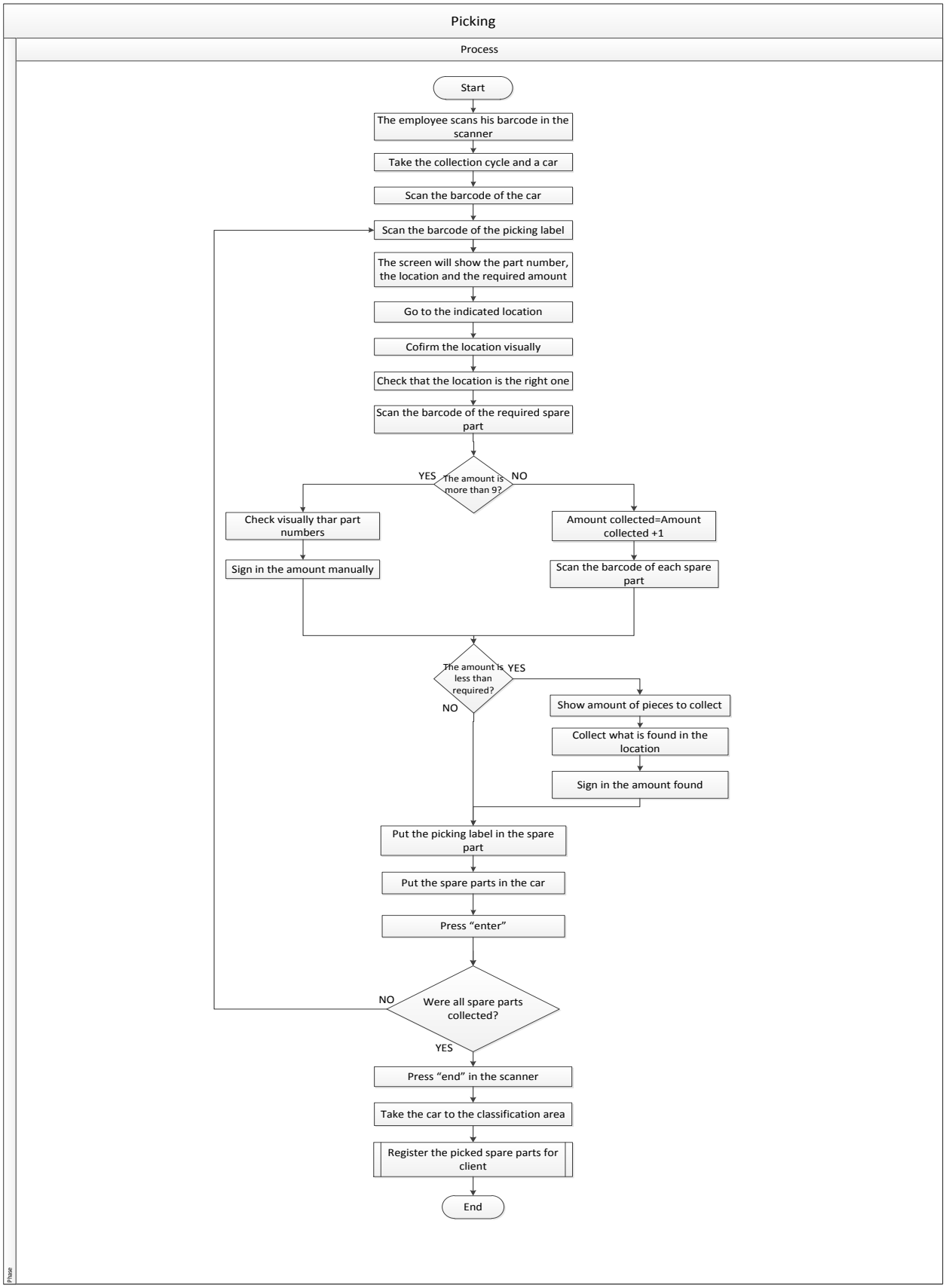
DISTRIBUCION DE CLIENTES POR RUTA

RUTAS	METROPOLITANA	CENTRAL	OCCIDENTE	ORIENTE	CLIENTES POR RUTAS
A1 W1	115 - 120 130 -131 - 133	233		424 422 - 407	9
A2 W2	104	206 - 236 - 241 243 - 244 - 253	309 - 328 - 334		10
A3 W3	103 - 105 - 110 - 128 - 132 - 135	210 - 231 - 233	312	401	11
A4 W4	120 - 131	207 - 237 - 238 239 - 240 - 250	303 - 319 - 337		11
A5 W5	104 -130 - 133		309 - 310 - 312 314 - 328 - 334	409 - 418 - 405	12
B1 W6	105 - 115 - 134	252 - 256	335 - 336	407 - 419 424 - 401 - 411	12
B2 W7	120 - 131 -132	254	322 - 330 - 338	403 - 420	9
B3 W8	130	230 - 241	319 - 301	400 - 402 415 - 422 - 426	10
B4 W9		206 - 231 - 232 236 - 238 - 243 244 - 257	337	410 - 423	11
B5 W10	103 - 104 - 105 110 - 112 - 128 135 - 134				8

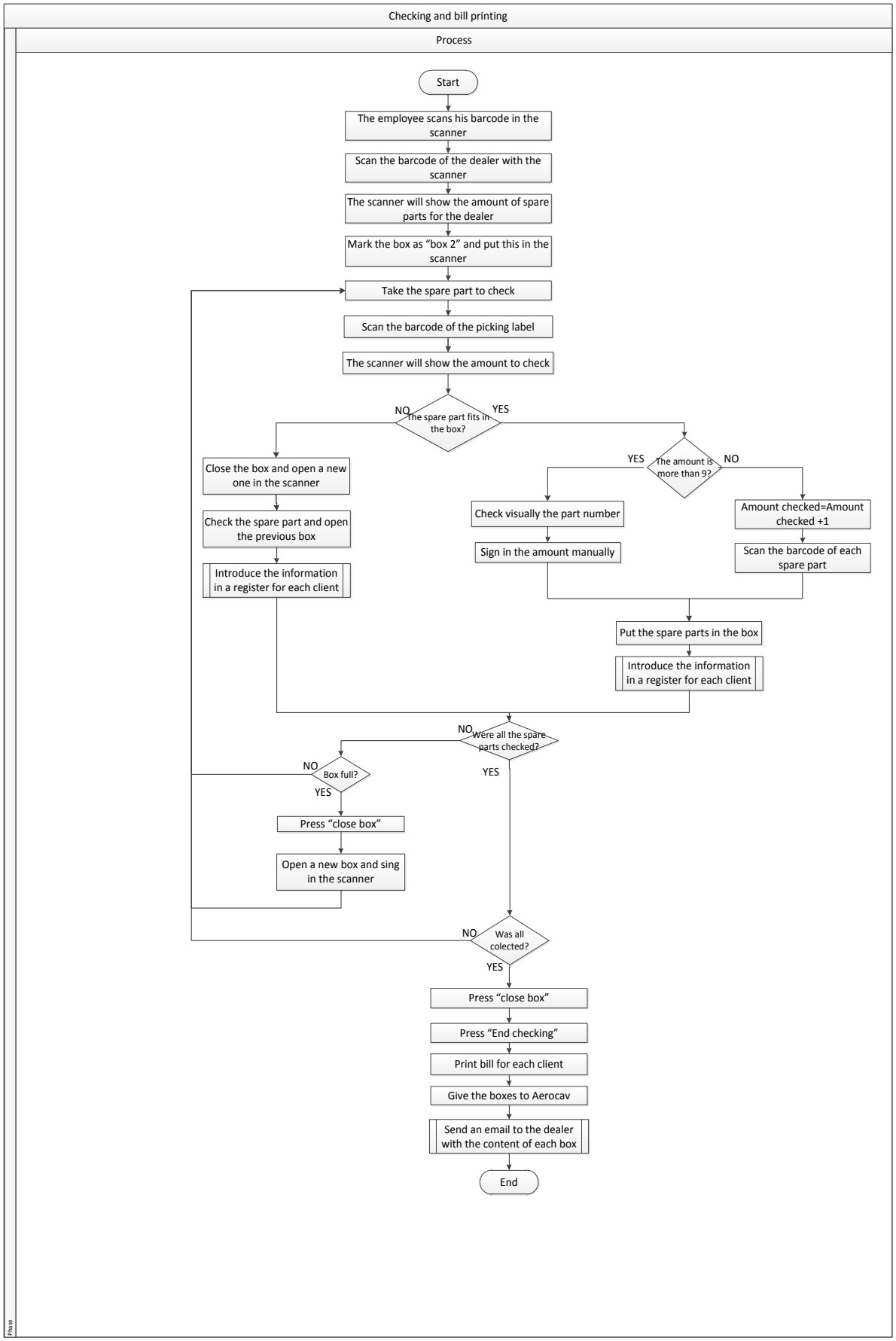
Annex 2 - Zones of the warehouse

	Warehouse zone	Type of spare part	Tool
Zone 1	A - B	Small spare parts	Half size trolley
Zone 2	C - D - E	Half sieze	Trolley
Zone 3	F	Glasses	Special trolley
Zone 4	P - Q - Z	Irregular spare parts	Trolley
Zone 5	T	Accesories	Trolley
Zone 6	NA01 - ND06	Big spare parts	Trolley
Zone 7	R	Heavy spare parts	Paddle
Zone 8	K	Irregular spare parts	Trolley
Zone 9	J	Security	Trolley
Zone 0	G	Big spare parts	Forklift
Zone X	New spare parts		
Zone F	Barn 3 Y 4	Half and big sieze	Forklift and trolley
Zone B	South reserve	Bumpers	Paddle
Zone C	NA01 - ND06	Big pieces with high locations	Forklift
Zone H	NE07 – NQ16	Autobody and motors	Paddle and forklift
Zone I	NE07 – NQ16	Autobody and motors with high locations	Paddle and forklift

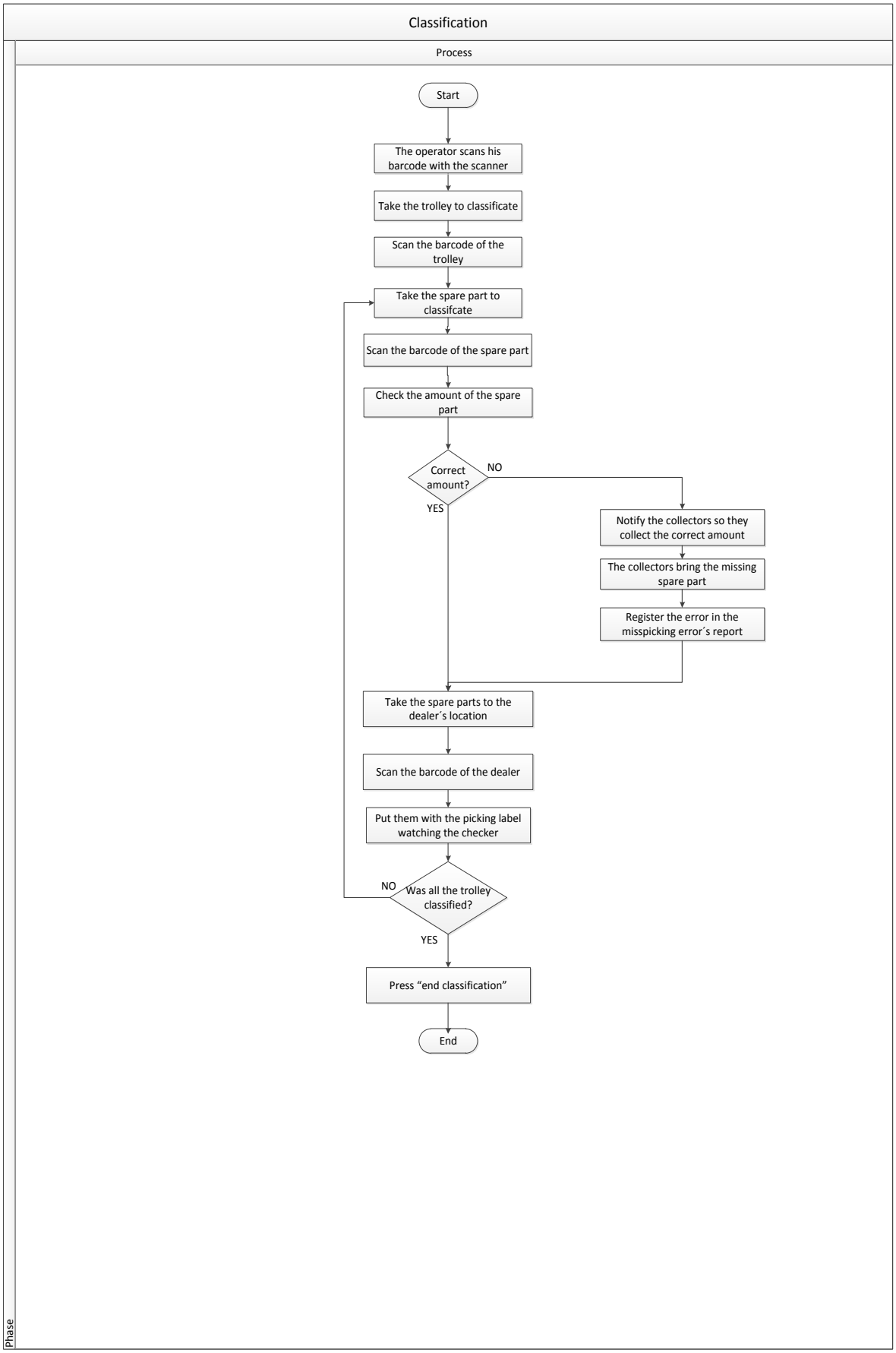
Annex 3 - Picking process



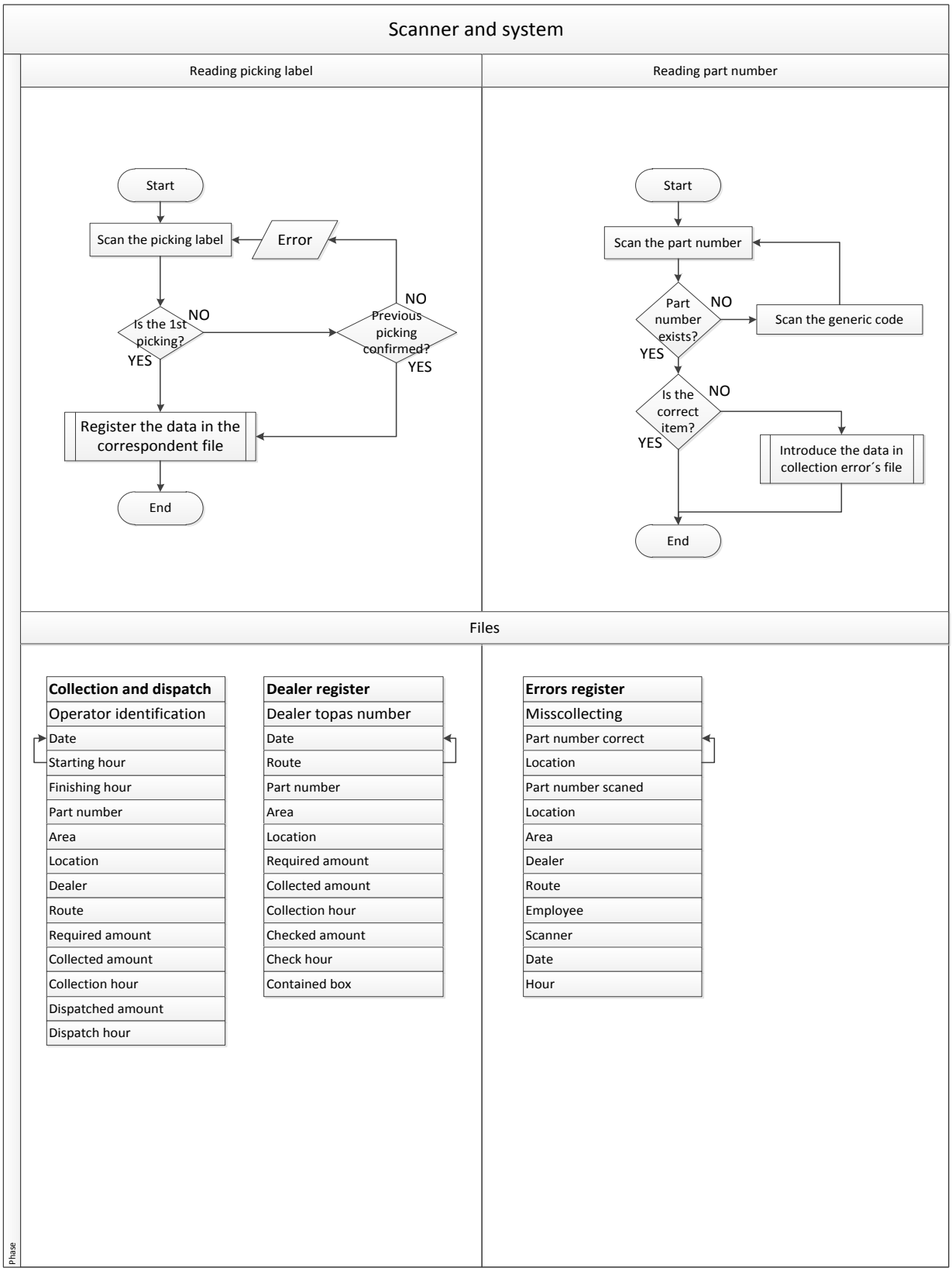
Annex 4 - Checking and packing process



Annex 5 - Classification process



Annex 6 – Scanner



Annex 7 - Planning for the application of the new system

Nr.	Activities	Explanation	Key point	Suggested time	Predecessor
1	Development of systems	Create the scanner systems, starting by the checking system	Consider in first stage that the checking is done against the bill and is only and adaptation of the checking boxes in the allocation	3 weeks	
2	Information campaing	Start a campaign that will explain the operators the changes that will come and their advantages	Make pamphlets and boards that prepare the operators to the changes	During all the development time	Simultanious with 1
3	Start training in checking system	Start the training process in the checking system, starting with two or three operators	Train two or three operators to use them as test subjects of the process	3 weeks	1
4	Testing of the checking system in operation	The trained workers should replace the use of checking notes for the scanner	Start the change in top a dealer per route, always one with low movement and with the checking notes just for cross checking	2 weeks	3
5	Make necessary adjustments to the system	After the system has been tested in operation make the necessary changes	Take the opinion of the workers and the results of the test as base for the changes	1 week	4
6	Train the rest of the operators in the checking system	With the system already prepared train the dispatch operators to start the use of the system	Train all the operators to ensure the proper use of the scanner	6 weeks	5
7	Start the implementation of the checking system	While the operators are getting ready in the training they must start using the system	In the first week each operator must use both the scanner and the checking note to evaluate his training, and always start with low movement dealers	6 weeks	Simultanious with 6
8	Fully implement the system	When all the operators are trained and tested start the official use of the system	Eliminate definitely the checking notes and give a time for full adapting, check for any failures an evaluate performance	3 weeks	7
9	Development of systems	Create the picking system	Create the picking system so it be able of store the information for use in the checking process	3 weeks	1
10	Start training in picking system	Start the training process in the picking system, starting with one or two operators from mezzanine area	Train one or two operators to use them as test subjects of the process	2 weeks	9,8

Nr.	Activities	Explanation	Key point	Suggested time	Predecessor
11	Testing of the picking system in operation	The trained workers should use the scanner as described in the new picking process in the mezzanine area	Use mezzanine area to test just the picking system without interact with the rest of the process and compare checking notes with picked	2 weeks	10
12	Make necessary adjustments to the system	After the system has been tested in operation make the necessary changes	Take the opinion of the workers and the results of the test as base for the change	Top 1 week	11
13	Train the rest of the operators in the picking system	With the system already prepared train the dispatch operators to start the use of the system	Train all the operators to ensure the proper use of the scanner	6 weeks	12
14	Start the implementation of the picking system	While the operators are getting ready in the training they must start using the system	Keep a constant track over the difference between picking file, order of dealers and checking file	6 weeks	Simultanious with 13
15	Fully implement the system	When all the operators are trained and tested start the official use of the system	Start printing the bills after the checking process is done, print the modified picking labels and adjust the checking system to compare against picked	3 weeks	14
16	Development of systems	Develop of the data collection system for misallocation	Develop this system to start evaluating the performance of the allocation area	3 weeks	9
17	Training in data collection system	Train the operator in the use of this system	Explain the advantages of the use of this system and it importance for the improvement of the processes	1 week	16
18	Implmentation of system	Start using the data collection system to store data about misallocation	Print files with the differences between order of dealer and picked to start the process and evaluate it performance	1 week	17, 14
19	Development of systems	Develop the new classification system	Develop the classification system so be able to classify according to what is located in each trolley	3 weeks	16
20	Start training in classification system	Start the training process in the classification system, starting with two or three operators	Train two or three operators to use them as test subjects of the process	3 weeks	19,15

Nr.	Activities	Explanation	Key point	Suggested time	Predecessor
21	Testing of the picking system in operation	The operators must start the use of this system every time they classify a trolley	Check with the picking labels that the dealer is the correct	From 1 to 2 weeks	20
22	Make necessary adjustments to the system	After the system has been tested in operation make the necessary changes	Take the opinion of the workers and the results of the test as base for the change	Top 1 week	21
23	Train the rest of the operators in the classification system	With the system already prepared train the dispatch operators to start the use of the system	Train all the operators to ensure the proper use of the scanner	From 1 to 2 months	22
24	Start the implementation of the classification system	While the operators are getting ready in the training they must start using the system	Keep a constant track over the difference between picking file, classification file and checking file	From 1 to 2 months	Simultanious with 23
25	Fully implement the system	When all the operators are trained and tested start the official use of the system	Use the reduced amount of picking labels, check if the absence of picking labels is producing any effect in the operation	From 2 to 4 weeks	24
TOTAL ESTIMATED TIME				**53 Weeks**	

Annex 8 - First stage diagram

Routes	Closing of orders by TDV	Printing of picking labels	Work assign	Picking	Classification	Packing	Bills printing	Loading material
A1 W1	3:45 (Day before)	03:55	04:00	08:10 08:50	08:20 09:00	08:20 09:15 Coffee brake 9:00 9:15	09:00 09:15 Coffee brake 9:00 9:15	09:20
A2 W2	08:30	08:40	08:45	08:50 09:30 Coffee brake 9:00 9:15	09:00 09:40 Coffee brake 9:00 9:15	09:00 09:55 Coffee brake 9:00 9:15	09:40 09:55	10:00
A3 W3	09:10	09:20	09:25	09:30 10:10	09:40 10:20	09:40 10:35	10:20 10:35	10:40
A4 W4	09:50	10:00	10:05	10:10 10:50	10:20 11:00	10:20 11:15	11:00 11:15	11:20
A5 W5	10:30	10:40	10:45	10:50 11:30	11:00 11:40	11:00 1:55	11:40 11:55	01:00
B1 W6	11:10	11:20	11:25	11:30 01:10	11:40 01:20	11:40 01:35	01:20 01:35	01:40
B2 W7	12:50	01:00	01:05	01:10 01:50	01:20 02:00	01:20 02:15 Coffee brake 2:00 2:15	02:00 02:15 Coffee brake 2:00 2:15	02:20
B3 W8	01:35	01:45	01:50	01:50 02:30 Coffee brake 2:00 2:15	02:00 02:40 Coffee brake 2:00 2:15	02:00 02:55 Coffee brake 2:00 2:15	02:40 02:55	03:00
B4 W9	02:15	02:25	02:30	02:30 03:10	02:40 03:20	02:40 03:35	03:20 03:35	03:40
B5 W10	02:55	03:05	03:10	03:10 03:50	03:20 04:00	03:20 04:15	04:00 04:15	04:20

Annex 9 - Second stage diagram

Routes	Closing of orders by TDV	Printing of picking labels and work	Picking	Classification	Packing	Bills printing	Loading material
A1 W1	3:45 (Day before)	03:55	08:05 08:50	08:20 09:00	08:20 09:15 Coffee brake 9:00 9:15	09:00 09:15 Coffee brake 9:00 9:15	09:20
A2 W2	08:30	08:40	08:45 09:30 Coffee brake 9:00 9:15	09:00 09:40 Coffee brake 9:00 9:15	09:00 09:55 Coffee brake 9:00 9:15	09:40 09:55	10:00
A3 W3	09:10	09:20	09:25 10:10	09:40 10:20	09:40 10:35	10:20 10:35	10:40
A4 W4	09:50	10:00	10:05 10:50	10:20 11:00	10:20 11:15	11:00 11:15	11:20
A5 W5	10:30	10:40	10:45 11:30	11:00 11:40	11:00 1:55	11:40 11:55	01:00
B1 W6	11:10	11:20	11:25 01:10	11:40 01:20	11:40 01:35	01:20 01:35	01:40
B2 W7	12:50	01:00	01:05 01:50	01:20 02:00	01:20 02:15 Coffee brake 2:00 2:15	02:00 02:15 Coffee brake 2:00 2:15	02:20
B3 W8	01:35	01:45	01:50 02:30 Coffee brake 2:00 2:15	02:00 02:40 Coffee brake 2:00 2:15	02:00 02:55 Coffee brake 2:00 2:15	02:40 02:55	03:00
B4 W9	02:15	02:25	02:30 03:10	02:40 03:20	02:40 03:35	03:20 03:35	03:40
B5 W10	02:55	03:05	03:10 03:50	03:20 04:00	03:20 04:15	04:00 04:15	04:20