GT-PANAMA THESIS SERIES
DISCLAIMER

This document was written by students at the Georgia Institute of Technology as part of the requirements to receive the degree Master of Science in Supply Chain Engineering. This is not a professional consulting report, but rather an attempt by students to explore supply chain issues, generally in a quantitative way that may not have been attempted heretofore. This document has been selected for release because the Georgia Tech Panama Logistics Innovation and Research Center believes that it offers ideas of interest to the community.

Reference in this thesis to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement, recommendation, or favoring by the Georgia Institute of Technology. The views and opinions of the author(s) expressed herein do not state or reflect those of the Institute nor the GT Panama Center, and shall not be used for advertising or product endorsement purposes.

Distribution Center: Inbound Process, Slotting, and Picking Strategy Reengineering

A Capstone Project
Presented to
The Academic Faculty

by

Gabriel Armien Dominguez
Patrick Kung Cheng
Santos Enrique Rivero Rodriguez

Advised by

Dr. John J. Bartholdi III, Advisor
School of Industrial and Systems Engineering
Georgia Institute of Technology

Praxedes Torres, MSc., Advisor
School of Industrial Engineering
Universidad Tecnológica de Panamá

Pete Viehweg, Advisor
School of Industrial and Systems Engineering
Georgia Institute of Technology

In Partial Fulfillment
of the Requirements for the Degree of
Master of Science in Supply Chain Engineering in the
School of Industrial and Systems Engineering

Georgia Institute of Technology
August 3rd, 2016

Table of Content

Table of Figures

Table of Graphs

Executive Summary

Distribution Center: Inbound Process, Slotting and Picking Strategy Reengineering

This document contains the findings of the project about the reengineering of the inbound process, slotting and picking strategies of a distribution center (DC). Some of the problems observed were long inbound processing time, lack of available locations for put away, and product stored between the aisles. All these issues make the DC looks like if there would be a lack of personnel and/or space.

To identify the reasons of these issues a series of interviews with the personnel of each area were done accompanied by the mapping of the overall operational processes. Data analysis was also done to determine the most popular moving products within the warehouse and the busiest or most visited locations to find out if their SKUs were located on the most optimal locations.

The result of this study was limited by data availability such as volume and weight of their products, times a product is handled in the warehouse, statistics about providers' failure to supply. Despise of, it was possible to work with their shipment, purchase, inventory data and process mapping to determine the cause of the bottleneck on the products' flow. It is caused by several reasons such as repetitive tasks done by each department. The delay on the inbound process is due to the double verification of the products; first, by the receiving department and then, by the warehouse department. Furthermore, the verification of 100% of products that arrives to the DC makes products that could be verified faster, wait until all products that have arrived before are ready to enter the warehouse.

Looking at the storage of the SKUs, the analysis showed that, by May 2016, almost 80% of their most popular SKUs were not located in convenient locations for fast picking because the warehouse is divided by zone and the supervisor of each zone organize items by family. The data also revealed some peaks on the flow of products, showing sometimes the entry of more products than what is shipped or vice versa, but this is thought to be due to the purchase department, which is out of the scope of this study.

In conclusion, we recommend to have a dedicated inventory control person in the receiving dock in charge of verifying the products when it arrives to remove the double

verification done by the receiving dock supervisor and the warehouse supervisors, also to keep track of the space utilization to check the possibility of keeping SKUs stored in pallets, to eliminate the palletizing and unpalletizing of the products when put away to the storage area. A re-slotting of their most popular products to reduce travel distance as well as proposal of data that needs to be collected and how to keep this data for further analysis is also given.

Introduction

This paper will provide a series of estimate benefits that will be achievable by implementing some changes into the distribution center (DC). There will also be a series of recommendations based on data analysis of their provided data that will help the DC to improve their operations efficiency.

1. Problem Statement

The company does not have a categorization of their fast-moving SKUs and a well-defined process in their inbound area for verification of products. Since they verify all the products, some of them may take up to five days to enter the warehouse, until then the products are not available to be ordered by the stores. Due to the unknown time that the freight is in the inbound area since its arrival, the SKUs are located on the first available space into their department because the warehouse coordinators doesn't know about the arrival of the SKUs prior they are ready to enter the warehouse.

2. Objectives

Analyze and propose a series of improvements that will impact positively the distribution center operations, so it may generate savings in terms of time (for inbound operations), lighten labor work for inbound, storage, and picking operations and make more efficient the space utilization in certain areas of the distribution center.

2.1. Specific Objectives

- Identify opportunities of improvement on their inbound, storage and picking processes.
- Analyze products' behavior to help define new allocation for products with higher movements within the distribution center.
- Analyze the alternative of re-arranging certain areas of the distribution center, so that the product flow becomes more efficient.
- Present a series of proposals and recommendations that can be implemented in a continuous basis to improve the distribution center's operations.

3. Background

The company is a local distributor for a wide variety of products with over 100 sale points in Central America. Therefore, import most of their products, store, add value, and ship to stores.

4. Justification

This project will recommend changes on the processes that are expected to:

- Reduce inbound operations time since the actual process for unloading products has a lot of opportunities of improvement.
- Improve space utilization by analyzing products seasonality and behavior to allocate them in adequate locations within the distribution center.
- Improve product flow from inbound to outbound by assigning most convenient areas for most popular SKUs near the dispatch area of the distribution center.
- Improve picking operation by changing picking strategy compared to how they are doing it nowadays

5. Scope

Because of the needs of the company and their emphasis on making better the processes, the scope of the project was limited to: inbound process, slotting of SKUs, and picking strategies. This is only within the main warehouse. The refrigerated zones are out of the scope because even though they have a lot of movements, there were not many changes that could be made because they are really small. During the scouting, it was also found that some of the racks present on the layout provided were not there and the amount of the levels of the racks varies between 3 to 7 levels.

6. Limitations

It is important to mention the constraints during the study.

- Time: the time of the study from the moment of the first meeting with the company until the moment of the delivery of this study was six weeks.
- Documentations: there was no detailed manual for the process and tasks of workers.
- Data:
    - There was no available data about the SKUs characteristics, including

dimensions and weight. Only the name of the product and its cost was provided.

- The locations data was not historical. They only had the locations of SKUs in inventory, meaning that the locations were got only for the SKUs in the warehouse during the realization of the study.
- No traceability of products due to unknown historical location of SKUs nor product ID.

7. Methodology

After meetings with some members of the company, logistics and purchasing managers, DC Managers and discussing the problem and expectations of the company, the project was divided in three phases:

7.1. Process Documentation and Interviews

The distribution center is located close to main route accesses and logistics parks. Because of the distance, the DC was visited eight (8) times during the study. The first four visits two students were designated to interview the coordinators and workers, while the other student was designated to verify all the physical available locations in the DC. During the 5th and 6th visit to the DC the measurement of all the distances were collected, as well as the total volume available for storage.

7.2. DC Layout Verification

The company provided a layout of the main warehouse (see Figure 1) and for two days each rack was checked one by one to be sure how many locations were actually on the warehouse to be able to know the real available space.

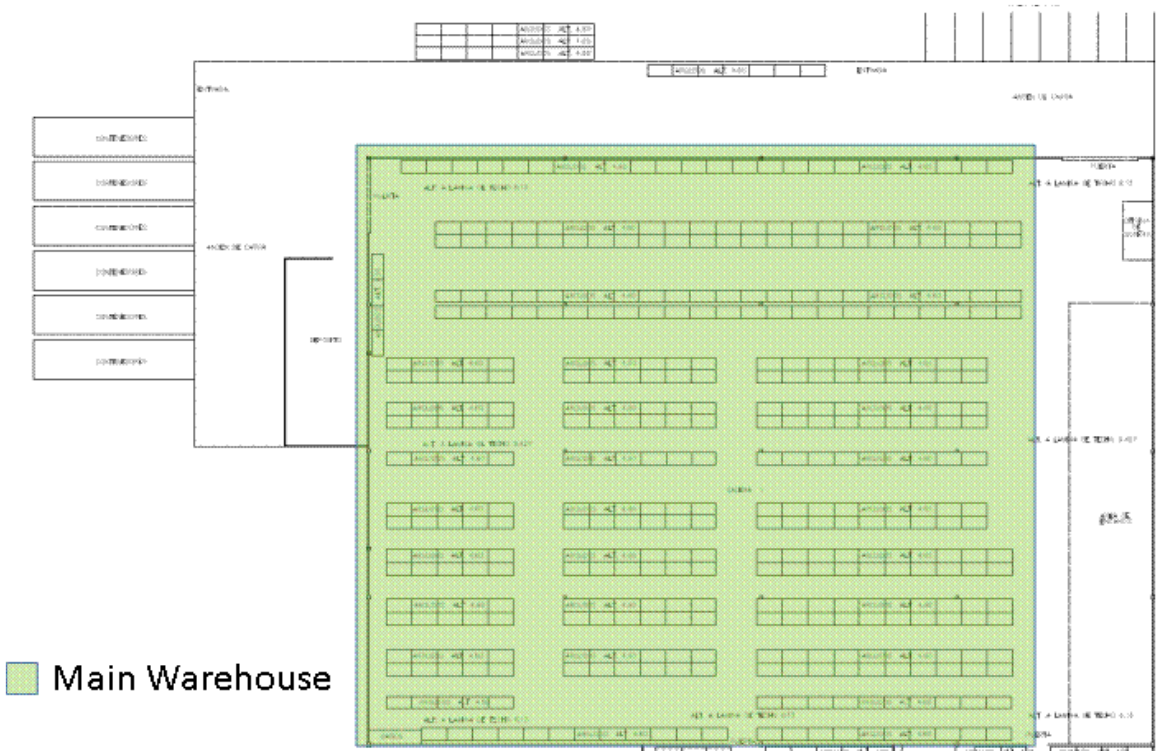


Figure 1 - Layout provided by the company

7.3. Data Analysis

For the data analysis was used the following software: SQLite3, Microsoft Excel, Microsoft Visio, and Java tools provided by Dr. J. Bartholdi. The company provided the:

- Layout of the warehouse
- Organizational chart
- Data:
    - Sales: Item Number, Transferred Units, Order Number, Customer number, customer name.
    - Purchases: Item Number, Units, cost, provider number, provider name.
    - Locations: inventory with the location of items on the warehouse.

8. Analysis

8.1. Layout

The layout provided only showed the horizontal view of the warehouse, not the vertical distribution. It is fair to mentioned that not all racks had the same amount of levels.

The warehouse is currently divided by type of products:

- Zone 100
- Zone 200
- Zone 300
- Zone 400 (full pallets)

The DC has 70 employees in total, including managers, supervisors, operators, and drivers.

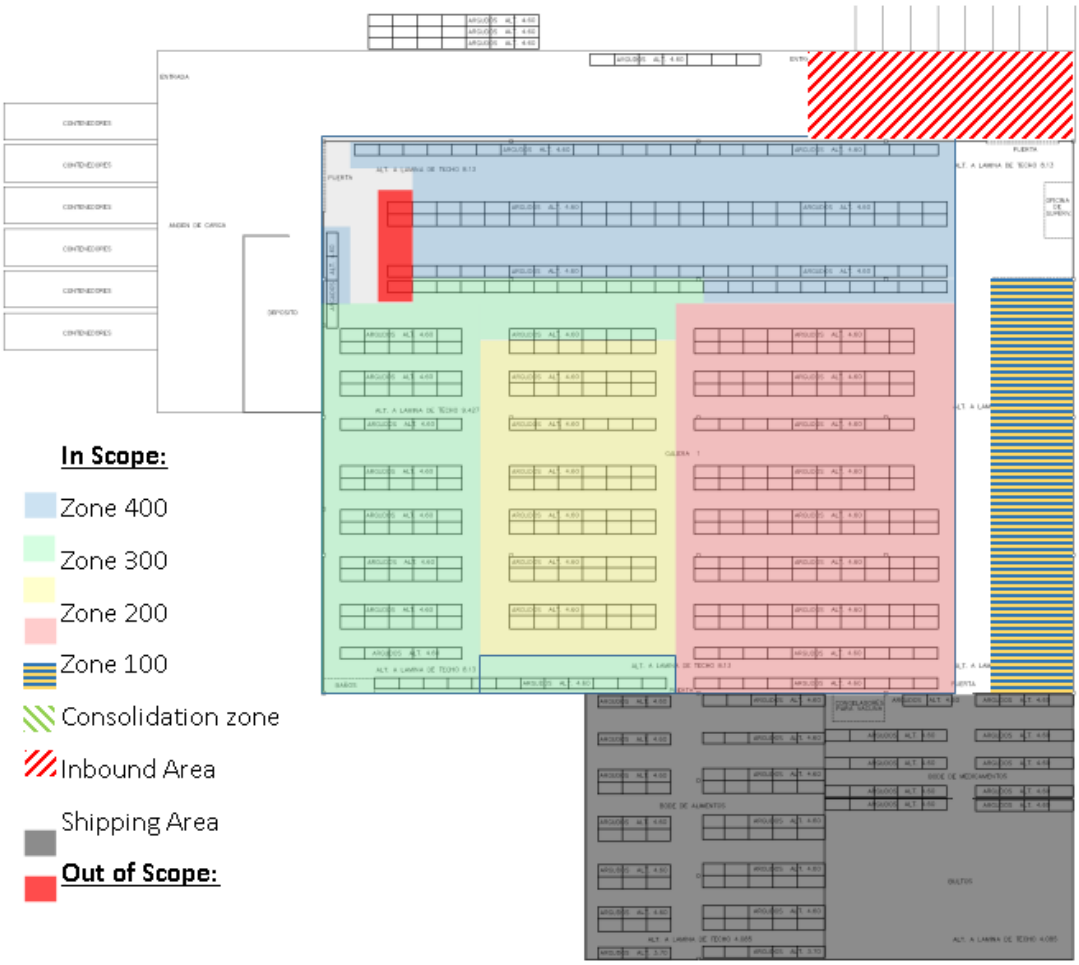


Figure 2 - Layout of the distribution center

As a proposal, we suggest keeping the current configuration by zone and re-slot most popular SKUs within each of its zones in the most convenient areas (see Figure 2). It would keep the DC working the same way, but more efficient since the picking and batching would require less time.

8.2. Process

8.2.1. Inbound Process

While reviewing the inbound processes by interviewing the workers, it was noticed that there is a big bottleneck for products to enter the warehouse after they are unloaded from the truck. As shown on the current process flow chart (Figure 3) of inbound operations, we noticed that the goods are verified twice by the receiving supervisors (inbound supervisor) and the warehouse coordinators on each zone depending to which zone the products belong to.

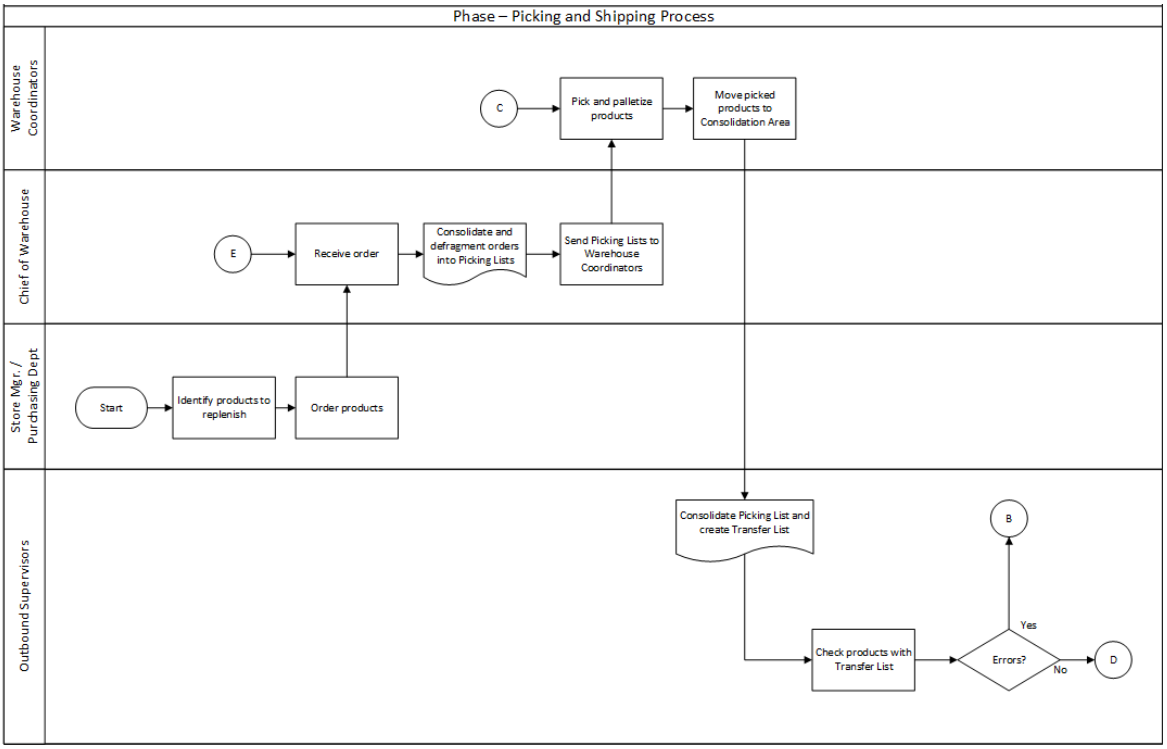


Figure 3 - Inbound process flow chart

After the purchasing order has been sent to a supplier, the Traffic Department sends a list to the inbound supervisor with the products in the container before the unloading assistants start the unloading process. The unloading assistants proceed to unload the container and palletize the products, then the forklift moves the pallet to an available space within the receiving area.

After that, the receiving supervisor must verify each product by opening the boxes and counting all the products. If there is a discrepancy like damaged products or not matching quantities, then he will notify the error to the inventory control department. In that case, they

will verify, collect backup information and contact the provider to get a refund or credit note for the discrepancy.

If everything is alright, then the receiving supervisor will notify the warehouse coordinator that they are ready to enter the products. The warehouse coordinator goes once again and verify the products and then, look for an available location and place them.

Proposal

To reduce double checking on inbound, they should have at least one person from the inventory control department permanently verifying the products that arrive (see Figure 4).

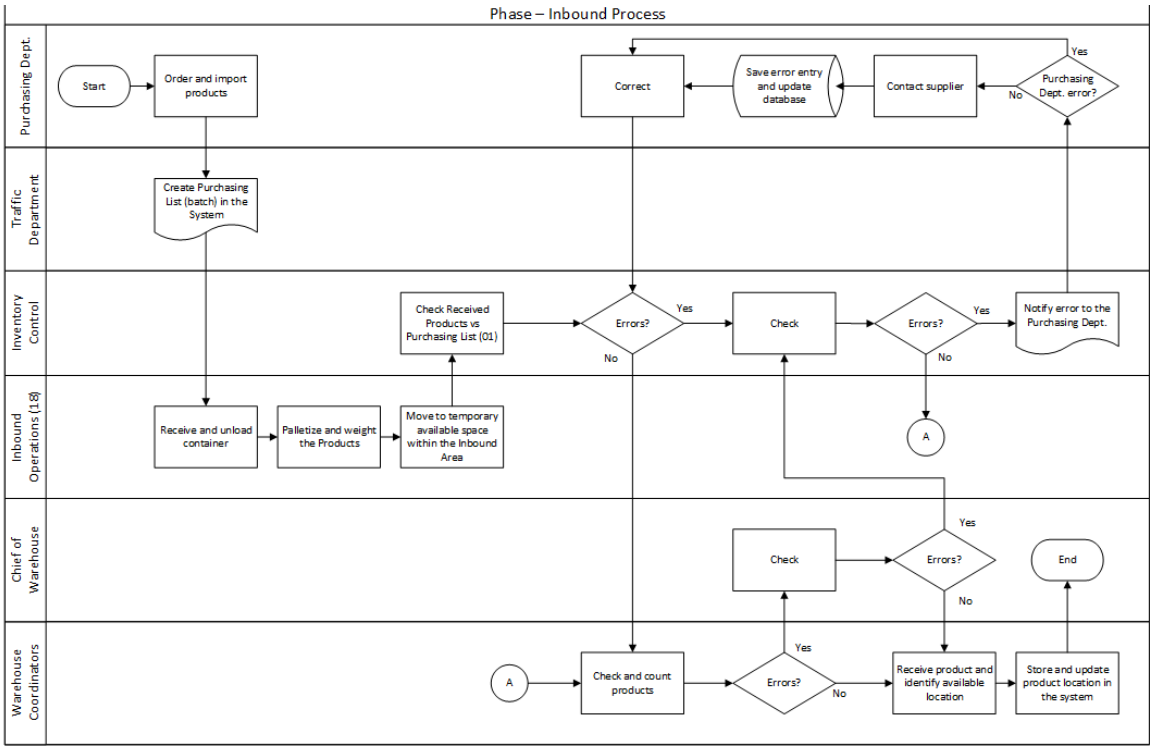


Figure 4 - Inbound process for proposal

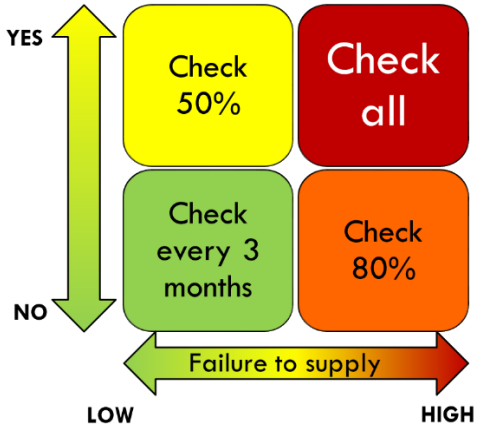


Figure 5 - Boston Consulting Group (BCG): checking decision tool

In addition, the database should reflect a category for fragile products, which will always have to be verified, and keep the record each provider. It is to be known that at least the first 4 months there will be lost in merchandise, but when something is found in the warehouse, even broken or incomplete, that will generate the record for the provider. After 5-6 months, the company will know which are the providers with the most failure to supply. These can be then checked every couple month together with those fragile items that may always be checked or not according to the record of the provider (see Figure 5).

8.2.2. Picking Process

The chief of warehouse receives the orders from the stores and divides them by zone. Each warehouse coordinator receives the picking list of the day. The picking list represents a store's order defragmented by the aisle where the pick is to be done. The pickers must now do the picking for the orders that are going to be shipped the following day

The zone 400 as it is only pallet load, the forklift moves the pallets directly to the consolidation area. The rest of the zones have a common method. They all do the picking and batch the orders of each store on pallets located on the main aisles for the forklift to move them to the consolidation area.

Proposal

Group SKUs by popularity and picks, but also consider piece or case picking. Piece picking can be done faster by one or two pickers, while pallet maximize volumes on batching (see Figure 6, left). The two batch on pallets represent each one a travel for the fork lift and they could clearly be batch on one single pallet box (see Figure 6, right).

Figure 6 - Proposed pallet box for batching (left) and current batching on pallets (right)

8.2.3. Outbound Process

The consolidation area consists on an area of 440.36 m^2 divided by stores. The outbound supervisor prints the transfer list to verify all items in the consolidation area. If there is an error with the shipment, then the supervisor will notify the chief of warehouse, who will verify it with the inventory control department and the respective warehouse coordinator. If the order is complete, then the products are consolidated in pallets to be moved to the shipping dock. They will be unloaded from the pallets and loaded into the truck to maximize the volume of products on the truck.

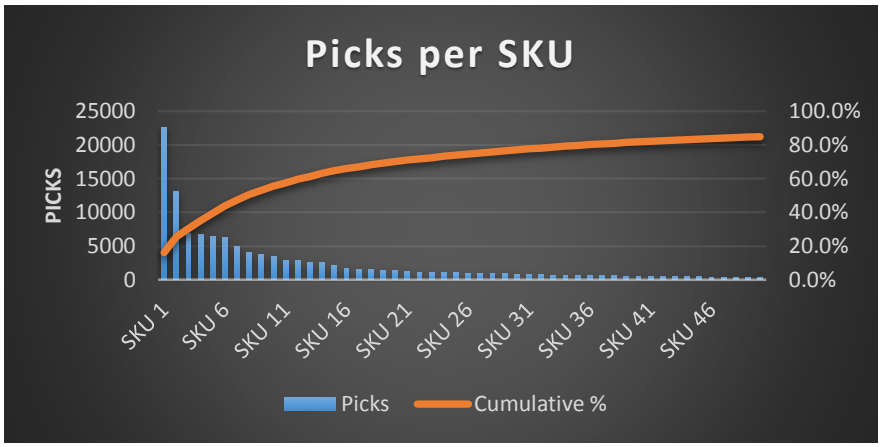
Outbound supervisors should also send a customer satisfaction survey to the store managers in order to receive feedback and keep track of their service level.

8.3. Data Manipulation

Data provided from January 2013 to May 2016 with their transferred SKUs. Since they don't handle a proper item master database, it was difficult to develop certain analysis with high precision. Therefore, we exclude all out-of-scope items.

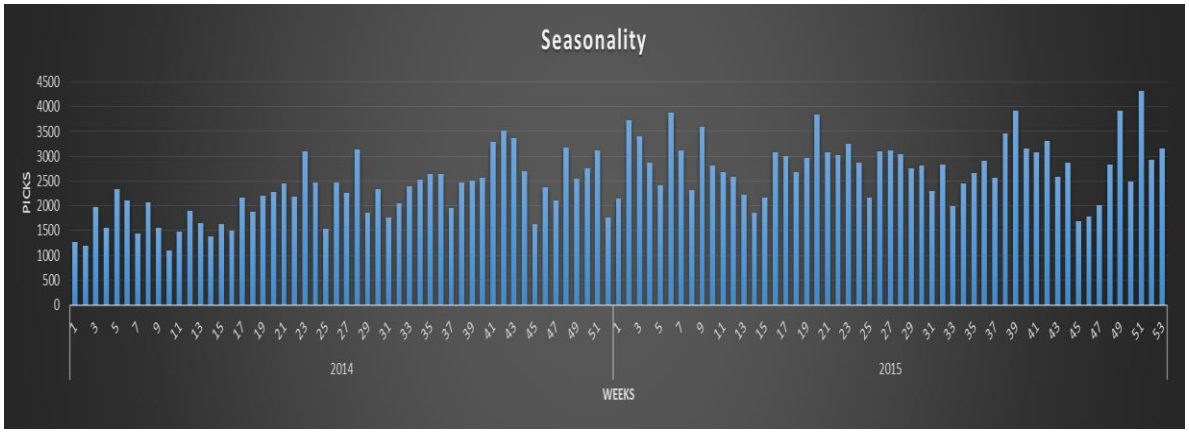
8.4. Pareto Analysis

We determine the popularity, volume in units transferred and value in dollars per SKU per zone. We could observe the most popular SKUs by zone (see Graph 1).



Graph 1 – Pareto of picks for the most popular SKUs

8.5. Seasonality



Graph 2 - Seasonality by picks 2014-2015

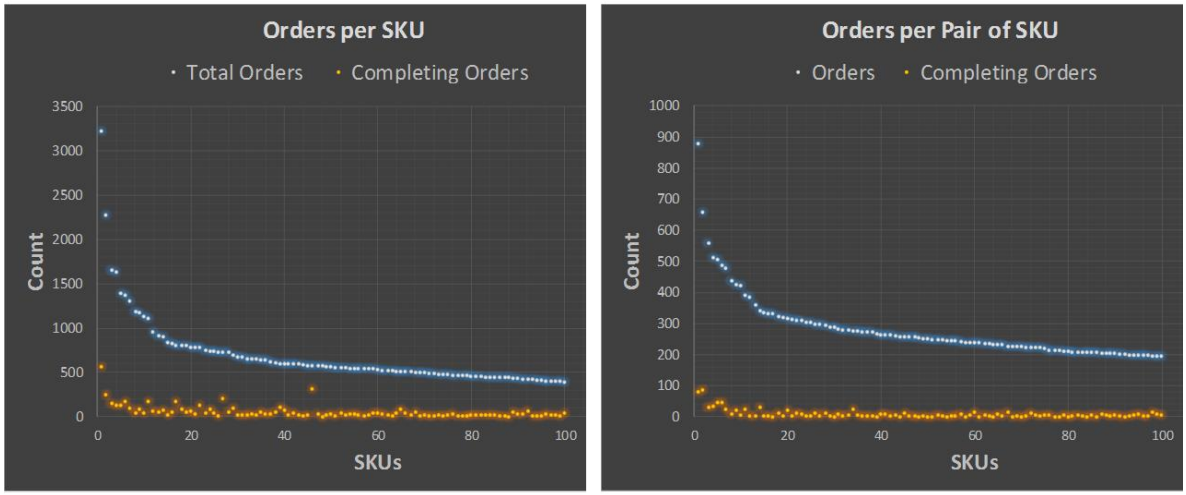
Transfers were higher during 2015 compared to previous years. They were, generally, busy on the second half of the year having a little slow down during the week 45. Pet supplies had most picks followed by agrochemicals, garden supplies and hardware tools.

8.6. Patterns and Behavior

Some popular SKUs had constant transfers, so they should have reserve storage in the convenient zone. Other products presented highly seasonal patterns, so they should be re-slotted according to its season to take advantage of the convenient locations. On the other hand, other products had no seasonality pattern or were new products, so they should be analyzed with more detailed.

8.7. Affinity

Dr. Bartholdi said that "affinity is easier to recognize and exploit if a typical order is small." (Bartholdi & Hackman, 2014). We could observe that some SKUs satisfied all the orders in which they appeared by themselves.



Graph 3 - Affinity of products: Orders per SKU (left) and Orders per Pair of SKU (right)

Furthermore, order completions are low because stores, generally, order different SKUs to make the most of the truck capacity and reduce transportation cost per item (see Graph 3**,** left). We could also observe affinity among pair of SKUs like: pet dryer with pet fan and bird cage with pet house (see Graph 3, right). According to Bartholdi (2014), the benefits of completing orders quickly include reduced work to consolidate orders before shipping. Therefore, it is highly recommended to store likely products together to reduce the picking distance and its associated costs.

9. Results

In general, lifting weights from 1.02 to 1.52 m requires less energy than lifting them from the floor to 0.58 m, from 0.58 to 1.02 m, or overhead 1.52 to 2.03 m. Therefore, "the goal is to keep an operator as comfortable and productive at the end of the shift as he or she was at the beginning", according to J.B. Mayes (Bond, 2014). According to Tompkins, a best practice for order picking is to assign the most popular SKU to the most easily accessed locations in the warehouse (Tompkins & White, 2003). Because 30% of the SKUs produce 80% of the picking activity, we can minimize the order picking travel time and bending moves by locating them on the most convenient locations.

When comparing the past picking behavior according to the data given of 2015 with the Proposal (re-slotting products within the same zone layout) we obtained:

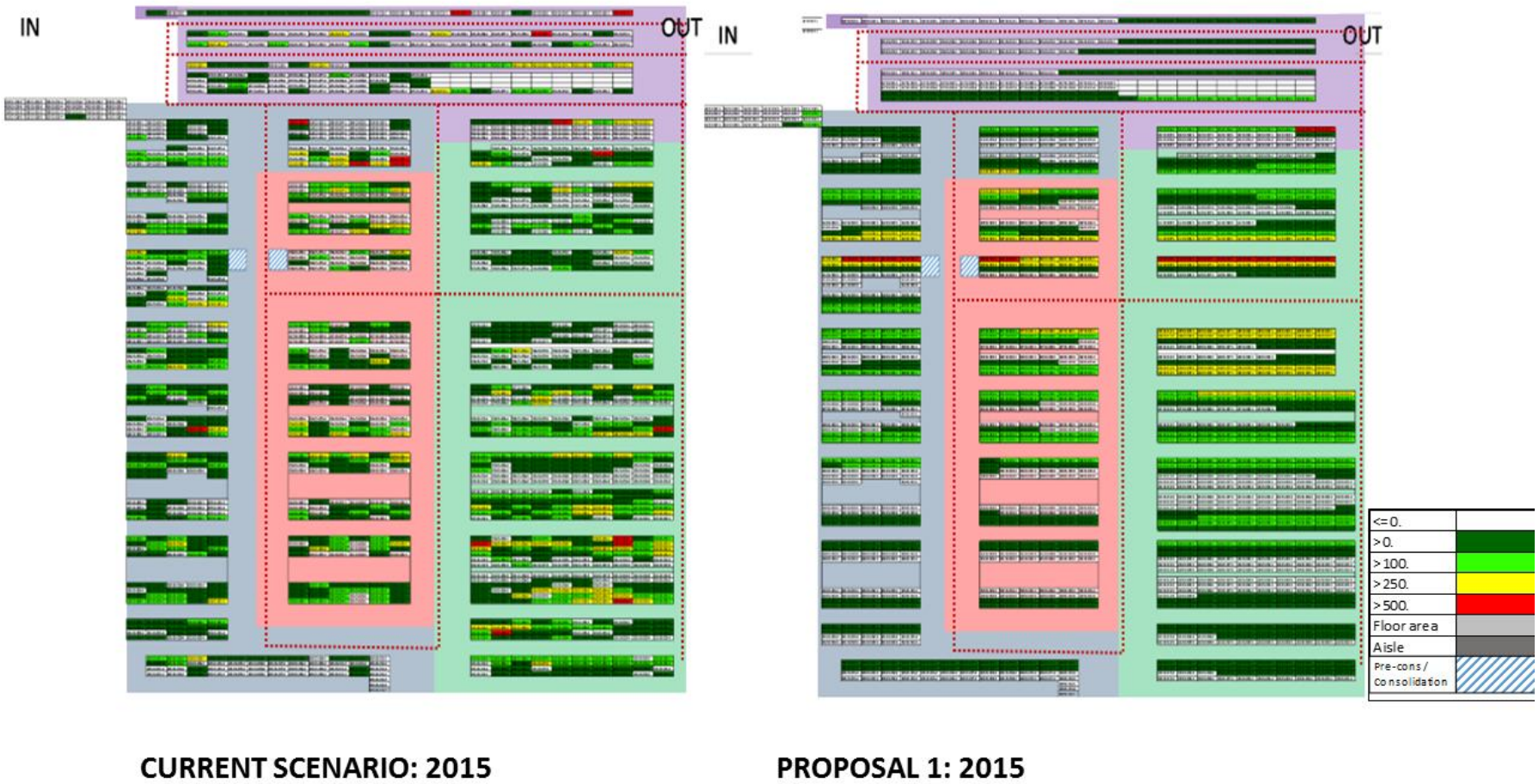
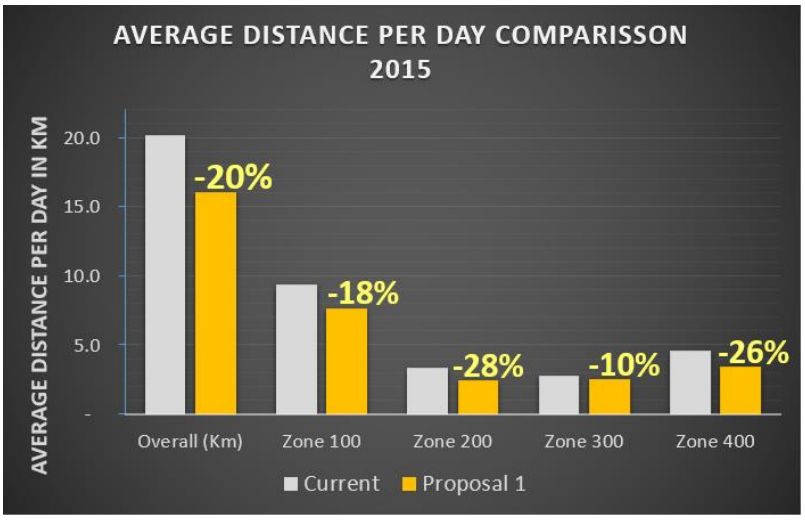


Figure 7 - Picking heatmap comparison for 2015

The “current” heatmap for 2015 reveals locations such as “211-01-001-2”, which had 763 picks while there were closer locations to the consolidation area and therefore, more convenient (see Figure 7). Proposal 1 produces an overall improvement of -20% in average travel distance per day.



Graph 4 - Average distance per day results for 2015

All zones would have had over 10% in distance savings for data given from 2015. Implementing this proposal has low operational impact because the warehouse would have to locate products according to their location ranking, affinity, seasonality, and taking in consideration the pick path to reduce visiting aisles (see Graph 4). They would keep their current zone configuration and apply the proposed process.

Recommendations

1. **Re-slotting and notification.** Locate SKUs into the best possible zone according to its picking frequency and availability. Therefore, warehouse coordinators should be notified when there are products in the receiving area waiting to be count and checked. This will give a head up and help to have better planning of the available locations.

2. **Key Performance Indicators.** It is well known that we cannot control what we cannot measure. Therefore, KPIs for the distribution center should be aligned with the company's strategy, be easy to understand, allow for action, be contextual, involve everyone (managers, assistants, drivers, etc.), and the results must be shared adequately to the employees according to their role.

   They already keep records to track their operations such as: number of SKUs transferred[1], employees and labor hours per month, cost of goods transferred per day per store[2] and amount of containers received and unloaded.

   The following indicators should be taken into consideration (SCM & SAP ERP, 2015):

   - Average order fill and order-line fill rate in percentage,
   - Customer order cycle time in days,
   - Transfer order line SKUs not fulfilled due to stock outs/aisles blocked,
   - Average dock-to-stock and pick-to-ship time,
   - On time inbound deliveries and outbound deliveries in percentage,
   - Average warehouse space utilization and average convenient zone utilization,
   - Average inventory turns per year,
   - Average order pick accuracy in percentage,
   - Inventory obsolescence and damaged inventory in percentage,
   - Average errors of SKUs incorrectly located in percentage,
   - Average number of times a product is handled.

   Companies with high perfect order rates carry less inventory, experience shorter cash-to-cash cycle time, and have significantly fewer stock-outs than their competitors (LINCS in Supply Chain Management Consortium, 2015).

3. **Better data collection.** To increase precision on further analysis it is necessary for the company to keep better track of everything that happens on the warehouse. For

[1] Indicators currently used by the *distribution center* on the file "*Compras de Abril 2016.xlsx*". Retrieved on June 16th, 2016.

[2] Indicators currently used by the *distribution center* on the file "*Items Despachados Abril 2016.xlsx*". Retrieved on June 17th, 2016.

example, vendors with high failure to supply might be checked always, while others may be checked once every two or three months.

4. **Visible Barcodes.** To improve picking, is important to have the barcodes on accessible and visible areas. Some labels are located on the third and fourth level of the racks, which is difficult for pickers since they have to go up twice to pick the product and scan the code. All codes must be located on an average height where the picker can have access to all of them from the floor. The result of locating the barcodes on the first level show an improvement of 13% in scanning time.

5. **Automatic replenishment.** In order to transform the warehouse into a distribution center, automatic replenishment based on POS data should be driven by point-of-sale (POS) data. It must result on order proposals from the DC to the stores.

Further Research

1. **Popularity of SKUs by Volume.** After having the volume for all SKUs, a popularity analysis should be done to determine which are the most moving volume SKUs in the warehouse. This could be useful to determine if there is correlation on the SKU popularity and its volume and consider if it would be beneficial to group some SKUs according to their volume.

2. **Warehouse Volume Flow.** To reduce high volume density peaks, it would be needed to analyze the volume of SKUs getting in and out of the warehouse, checking for opportunities where to balance the flow to avoid having very high or very low space utilization. Share the results with the Purchasing Department and the store managers to work on a demand strategy that would benefit the company and reach its goals.

3. **Warehouse Management System.** A warehouse management system (WMS) would help to keep track of product changes, dimensions, visibility and pickers productivity such as SAP WMS module. No WMS is perfect. It must be adaptable for the company needs.

Conclusions

After analyzing the data available, interviewing the personnel, and visit the main warehouse, a proposal is presented to reduce the travel picking distance. It suggests to locate the most popular SKUs in the convenient zone, taking into consideration products' affinity, pick path and seasonality.

The proposal showed to produce distance savings by 20% with low operational impact and no physical modifications to the warehouse' s layout. Nevertheless, this proposal does not contemplate the forklift's travel distance from the batching areas to the consolidation area. These trips were not calculated due to lack of information on the order batch.

Furthermore, the current process presented a bottleneck in the inbound area due to the duplicity of count-and-check steps because of space and personnel constraints. But this can be eliminated by empowering Inventory Control to verify the entering products with the decision tool. In fact, the proposed process also suggests that warehouse coordinators should be notified that products from their zones have arrived, even before the product is checked. These changes to the current process would potentially increase the dock-to-stock time.

Other recommendations should also be applied such as start collecting data (weight, dimensions, fragility, timing), enforcing key performance indicators, customer satisfaction survey, put the different barcodes on the first level so that they become accessible to the pickers, and set visible signs for each aisle. Further research is also recommended such as analyzing the popularity of SKUs by volume, warehouse's volume flow and a warehouse management system (WMS).

In conclusion, the company should implement the proposal to take advantage of their convenient locations and reduce travel distance. This proposal has low operational impact, but has to be accompanied with updated product affinity and seasonality analysis per season. The inbound area should have employees dedicated to count-and-check the products in order to reduce double checking and reduce dock-to-stock time. Therefore, the pipeline inventory will be reduced as the receiving time is reduced.

References

Bartholdi, J. J., & Hackman, S. (2014, August). Warehouse and Distribution Science. *96*. Retrieved July 25, 2016, from www.warehouse-science.com

Bond, J. (2014, February). Ergonomics: Finding and maintaining the golden zone. *Modern Material Handling Magazine*. Retrieved July 26, 2016, from http://www.mmh.com/article/ergonomics_finding_and_maintaining_the_golden_zone

LINCS in Supply Chain Management Consortium. (2015). *Supply Chain Management Principles Certification Track* (1.19 ed.). Florida. Retrieved July 27, 2016

SCM & SAP ERP. (2015, February 2). *SCM & SAP ERP*. Retrieved July 27, 2016, from Warehouse Key Performance Indicators (KPIs): http://scminerp.com/2015/02/warehouse-key-performance-indicators-kpis/

Tompkins, J. A., & White, J. A. (2003). Facilitates Planning. *John Wiley and Sons*. Retrieved July 2016