ISCTE Business School
Instituto Universitário de Lisboa

A MULTI-SCENARIO ANALYSIS TO IMPROVE LAYOUT EFFICIENCY

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Acknowledgments

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Abstract

The ability to compete is paramount and efficiency, regardless of the organisations' overall approach, is an issue companies continuously strive for. In every supply chain, the logistics costs represent a large portion of overall costs, and hence the warehousing costs. Although the storage of products by itself does not add value to the customer, it has an immediate impact on these operation costs.

Lauak Portugal is a partner factory of Groupe Lauak, a French group that owns a set of industrial companies supplying the aeronautical market. Aiming the layout costs reduction, it is inside its final products warehouse that this research is carried out.

Excluding inventory costs, the picking activity alone represents about 55% of the warehousing costs (Drury, 1998). Additionally, travelling during the picking activity is estimated to require about 50% of the time of the resources (Tompkins et al., 2010). Supported by this assumptions, 44 scenarios are analysed and compared, mixing storage assignment policies and alternative picking routes strategies.

Both qualitative and quantitative approaches are used in this research, based on data collected from interviews, observation, documentation and archival records. A case study approach is conducted following literature recommendations (Voss *et al.*, 2002; Yin, 2018).

Findings showed that travelling distance can be reduced by about 64% when the class-based storage is used, following their picking frequency, along with a pre-selected picking route.

Key Words: Logistics, ABC Analysis, Picking, Warehousing, Storage Assignment

JEL Classification System: M11; D24; L62; Y40

Resumo

A capacidade de competir é primordial e a eficiência, independentemente da abordagem geral das organizações, é uma questão que as empresas continuamente se esforçam para atingir. Em todas as cadeias de abastecimento, os custos logísticos representam uma grande parte dos custos totais e, consequentemente, dos custos de armazenagem. Embora o armazenamento de produtos por si só não acrescente valor ao cliente, ele tem um impacto imediato sobre os custos de operação.

Lauak Portugal é uma fábrica parceira do Groupe Lauak, um grupo francês que possui um conjunto de empresas industriais que abastecem o mercado aeronáutico. Visando a redução dos custos de layout, é dentro do seu armazém de produtos finais que esta pesquisa é realizada.

Excluindo os custos de stock, a atividade de picking por si só representa cerca de 55% dos custos de armazenagem (Drury, 1998). Além disso, estima-se que as deslocações durante a atividade de picking represente cerca de 50% do tempo dos recursos (Tompkins et al., 2010). Com base nestas premissas, 44 cenários são analisados e comparados, misturando políticas de armazenamento e diversas rotas de picking.

Ambas as abordagens qualitativa e quantitativa são utilizadas nesta pesquisa, com base em dados recolhidos a partir de entrevistas, observação, documentação e registros de arquivos. Estas abordagens são conduzidas com base nas recomendações da literatura (Voss et al., 2002; Yin, 2018).

Os resultados mostraram que a distância percorrida pode ser reduzida em cerca de 64% quando a políticas de armazenamento “Class-Based” é utilizada, seguindo a frequência de picking, juntamente com uma rota de picking pré-definida.

Key Words: Logistics, ABC Analysis, Picking, Warehousing, Storage Assignment

JEL Classification System: M11; D24; L62; Y40

Executive Summary

Competitiveness is paramount and efficiency, regardless of the company's overall approach, is an issue companies continuously strive for. Although the storage of a product itself does not add value to the customer (Tompkins and Smith, 1998; Carvalho, 2018), it has an immediate impact on the warehouse operation costs (Tompkins and Smith, 1998; Rushton et al., 2017).

Warehousing costs are an essential key in the overall costs a company has to support and, not considering inventory costs, the picking itself represents about 55% of the warehousing costs (Drury, 1998). Additionally, travelling during the picking activity is a major cost in warehousing, and it requires about 50% of the time of the resources (Tompkins et al., 2010). Even small savings in this travelling time can have a generous impact in the costs of the operation.

Lauak Portugal is based in Setúbal, Portugal, and it is specialized in transforming metal sheets in single aircrafts components and outside structures. This aerospace environment was the selected one to be the study field of this research. Service quality and fulfilment of due dates to the customers are relevant in this industry. Although most products are developed jointly with the customers, the cost issue is a key aspect in maintaining the competitiveness of the plant itself within the group.

The purpose of this research is to improve the internal costs in its finished product warehouse, which is considered as critical for the plant, affecting directly the delivery process to the final customer and, hence, the competitiveness.

Based on three conditions developed by Yin (2018), the methodology adopted in this project complies with the guidance of a case study, and it is structured following the recommendations purposed by Voss et al. (2002) and Yin (2018). The project went through several steps:

1. Identification of the initial situation, which undertook both qualitative and quantitative approaches. Qualitative using interviews to the managers of the area and the plant to perceive the warehouse purpose and the overall organisation of the facility; and quantitative as to collect data concerning distances and volumes of activity inside the warehouse.
2. Generation of theoretical scenarios, based on the literature, resulting from (a) picking routes and (b) storage assignment (Hausman *et al.*, 1976; Ratliff and

Rosenthal, 1983; Goetschalckx and Ratliff, 1988; Hall, 1993; Petersen and Aase, 2004; De Koster et al., 2007; Roodbergen et al., 2008; Chan and Chan, 2011; Çelk and Süral, 2014; Carvalho et al., 2018). 66 scenarios were initially considered ([(a)=22] * [(b)=3]), but only the ones suited for the company were analysed in depth (22 picking routes and 2 storage assignment);

3. Simulation to evaluate the efficiency of different scenarios, allowing the travelled distances comparison between each of them. Data collection was mostly conducted using direct observation and measurements, as the plant's information system did not have that information systematised. Although time-consuming, this approach allowed for a better quality of data.

Findings showed that the picking routes did not have much impact on the distance travelled during the picking activity, when analysed in absolute values, which is contrary to findings from other researchers (see, for instance, Rushton et al., 2017). When the analysis is made considering relative values, the conclusions showed to be more surprising. The unexpected findings might result from the space constraints in some areas of the warehouse, as it does not follow a typical shape. The layout and the products' organisation based on the families, on the other hand, showed to be a significant aspect in reducing travelling distance as they can reach savings between 38,45% and 46,25%, when the storage strategy is random, and above 64% when it is class-based.

Although this research was developed in a specific factory, the proposed methodology can be adapted so other companies, which desire to evaluate their internal policies, can find more efficient storage solutions.

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1 Introduction

This first chapter will introduce a succinct view behind the project's framework, that justifies the investigation relevance. The respective research question is then established, acting as a guideline to the project development. Afterwards, the main goal is highlighted, as well as the specific milestones required to reach that major objective. Right after that, the overall methodology adopted in this project is disclosed. The last two sub-chapters are intended for the scope of the project and its structure.

1.1 Problem Statement

Keeping a product stored for a certain period does not add any value to the final customer, which is something that has been gaining companies' attention over time (Tompkins and Smith, 1998; Carvalho *et al.*, 2018). For this reason, and because warehouses might be a competitive factor in many supply chains, companies began to care about that activity which has an immediate impact on their costs (Tompkins and Smith, 1998; Rushton *et al.*, 2010). Since then, managers all over the globe decided to put some effort in making warehouse's internal processes more efficient, once they are expensive and should be aligned with the whole supply chain's strategy (Rushton et al., 2010).

This research focuses on a company – Lauak Portugal – a partner plant of an aerospace metallurgic French group: Groupe Lauak. Having plants in many different countries, the group plants compete among themselves for company contracts. Service quality and fulfilment of due dates to customers are relevant in this industry. Although most products are developed jointly with the customers, the cost issue is a pertinent aspect for maintaining the competitiveness of the plant within the group. It is thus essential to continuously monitor costs while looking for strategies that allow reducing them. Warehousing costs, and particularly picking-related costs, play a vital role in this search.

In accordance with Tompkins and Smith (1998), Bowersox *et al.* (2002), Rushton *et al.* (2010), Bartholdi and Hackman (2017) and Carvalho *et al.* (2018), a traditional warehouse has 4 main activities: receiving, storage, picking, and shipping. The company considers that the activity that has the highest impact on the internal warehousing processes is the picking activity. In fact, Drury (1988) showed that, excluding inventory costs, the picking activity alone represents about 55% of the warehousing costs. In

addition, among all the company's warehouses, the picking in the final product warehouse emerged as one of the critical processes inside this plant. The fact that the company does not have any pre-selected picking policy or storage assignment strategy, these warehousing processes are delaying all sales and shipping procedures upstream.

Other research, this time conducted by Tompkins *et al.* (2010), stated that travelling between and across aisles, searching for product's location during the picking, represents 50% of the total time spent inside a warehouse. Based on this statistic, and after discussing it with the company, it was decided to propose a solution that would reduce the travelled distances inside the warehouse, being this variable considered as the criterion of analysis.

Considering these assumptions, the purpose of this research is to improve the warehousing costs, contributing to its competitiveness inside the group, by analysing, simulating, and improving the picking process.

1.2 Research Question

The research question by which the project is being guided for is: "How to improve the picking processes efficiency in the final product warehouse of Lauak?"

1.3 Objectives

This project aims the assessment of picking policies to reduce warehousing costs. For that, there are some specific milestones that need to be accomplished. The first one is to map the warehouse's internal processes, in order to understand the internal dynamic. After that, and to study the routes pickers take inside the warehouse, its measurements are critical to the analysis. Thus, it is needed to collect the distances across and between aisle and shelves. Then, after the picking routes' selection, several alternative theoretical scenarios are developed and simulated.

Being this said, the milestones of this project are:

- To map the warehouse internal processes;
- To measure the warehouse distances;
- To select and create alternative theoretical scenarios;

- To compare the current situation with the developed scenarios;
- To present final recommendations for the company.

1.4 Methodology

This research is based on a case study approach (Voss et al., 2002; Yin, 2018), and involves several consecutive research steps:

1. Step I – Characterizing the Current Operation in the Warehouse;
2. Step II – Defining a Set of Alternative Theoretical Scenarios;
3. Step III – Assessing and Comparing Alternative Theoretical Scenarios;
4. Step IV – Presenting Recommendations for the Company;

1.5 Scope

Lauak Portugal owns four warehouses: two for raw material (thin and thick), one for work-in-process and one for the final product. The company considered that the picking process in the final product's warehouse is consuming an excessive amount of time and, for this reason, this project is focused in this specific warehouse.

1.6 Structure of the Project

This project is structured as follows:

Chapter 1 – Introduction: The project's introduction, where the major objective, respective milestones, research question, methodology, scope and structure are briefly presented.

Chapter 2 – Literature Review: Acting as the theoretical support to the project, this chapter will develop the concepts, techniques, and strategies which previous investigations and international literature have published related to logistics, warehousing management, picking routes, and storage strategies.

Chapter 3 - The Company: LAUAK Portugal: This chapter will be used to present the company, contextualizing its activity and describing the warehouse's current situation, where its internal processes, strategies adopted, and ways of work are identified.

Chapter 4 – Methodology: With the theoretical background analysed in chapter 2, the choices made on this project are going to be justified in the methodology phase, as well as the steps that need to be taken in order to achieve the major goal.

Chapter 5 – Case Study: In the Case Study's chapter, the analysis is then detailed. The methods behind the travelled distances' calculations are going to be explained, as well as how the products reallocation was performed. This chapter finishes with the results' assessment, followed by the improvements suggestions.

Chapter 6 – Conclusion: The conclusions are finally presented, attempting the reflection about the developments, results, limitations, and further work.

2 Literature Review

The purpose of this chapter is to present the theoretical background that will support the project. This will lead to a literature review over the approaches and tools adopted by the researchers in their previous studies, to address similar challenges.

Recognizing warehouse management as the scope of this project, the logistics' concept will be first developed. Then, warehouse internal operations are clarified, describing the different features related to this project, detailing the adopted layout design.

2.1 Logistics Management

It is not easy to define Logistics because it depends on the environment where it lies in. However, a definition adopted by some authors (Stock and Lambert, 2001; Rushton *et al.*, 2010; Carvalho *et al.*, 2018), belongs to the Council of Supply Chain Management Professionals (CSCMP, 2013: 117), which defined *Logistics* as:

> "The process of planning, implementing, and controlling procedures for the efficient and effective transportation and storage of goods including services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements."

Rushton *et al.* (2010: 4) defined this concept as "a diverse and dynamic function that has to be flexible and has to change according to the various constraints and demands imposed upon it and with respect to the environment in which it works."

Another perspective, this time suggested by Bowersox *et al.* (2002) is that Logistics is a supply chain process that combines internal and external activities creating and moving value downstream to satisfy customer requests.

Lastly, Christopher (2016: 2) defines Logistics as "the process of strategically managing the procurement, movement, and storage of materials, parts and finished inventory through the organization and marketing channels."

All these previous perspectives may seem complex, but it is possible to make them simpler to understand when logistics' main purpose is clarified. According to Carvalho

et al. (2018), logistics aims to offer the highest possible level of customer service, while attempts to decrease lead time response and service costs. Christopher (2016), based on Ohmae (1982), presented his view over this problem, saying that, in order to achieve competitive advantage, it is crucial that companies focus themselves on "The strategic three C's": Company, Customer and Competitors. This advantage will rise if companies are able to adapt themselves to the market, differentiating from the competitors, always trying to offer what customer is willing to pay for (Christopher, 2016). After establishing that, companies must ask themselves three questions, to make sure the strategy is going into the right direction: (1) are the market segment and customer requirements well defined; (2) are the internal processes correctly structured to answer to those customer needs; and (3) do competitors have better operational conditions, making possible to reach the desired competitive advantage (Ohmae, 1983).

Carvalho *et al.* (2018) supported Christopher (2016) meaning that the logistics concept's complexity may decrease when companies fully understand the three "Logistics Attributes" (Fig. 1). In order to decide which strategy should companies follow, the balance between the *Time*, *Cost*, and *Service Quality* must be as much accurate as possible, being designated as "Trade-offs".

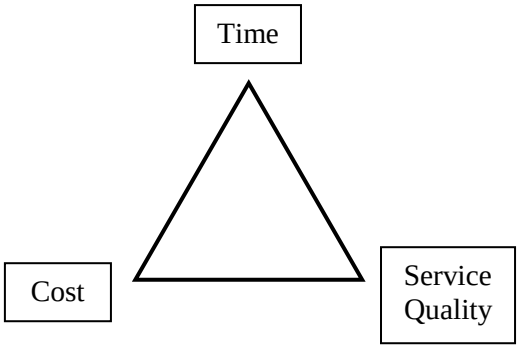


Fig. 1 - Logistics Attributes (Adapted from Carvalho et al., 2018)

The upper attribute represents the amount of time logistics service is performed, depending on how long the customers are willing to wait for a service/good. The cost is related with the system efficiency, meaning that the cheaper a company can make its process, the more efficient the logistic process is. The same is for the service quality: the better the service provided, the more valuable the process becomes.

Depending on the service/good it is being provided/sold, each vertex has its own relevance. It is impossible to offer the three attributes at the same time, but all of them need to be (somehow) incorporated in the strategy. For this reason, companies need to

assess the system and decide which attribute the client values most, in order to choose where the focus should be.

Depending on the researcher, literature can identify several logistics activities that help companies serving the final customer in the shortest possible time, aiming the lowest possible cost, at the best service quality.

Coyle *et al.* (1992) mentioned the transportation, packaging, materials handling, order processing, and forecasting as the main logistics activities companies should consider. Inventory and warehouse management, facilities network and information/communication control are later added to the list by Bowersox *et al.* (2002) and Rushton *et al.* (2010). Stock and Lambert (2001) and Carvalho *et al.* (2018) also stated other two logistics activities: procurement and reverse logistics; and production planning and client service, respectively.

It is possible to group these activities into distinct categories. Carvalho (1996) suggested five categories: Facilities Management, Inventory Management, Communication, Material Handling, and Transportation. Stock and Lambert (2001) clustered them as it is shown in Table 1.

Table 1 - Logistics Activities (Adapted from Stock and Lambert, 2001)

Activities	**Description**
Transportation	Physical movement or flow of goods across the supply chain and between players.
Packaging	Protect the product from damages during storage and transportation stages.
Materials Handling	Control the movements of raw materials, in-process inventory, and finished goods between storage areas, and from production last stage to the logistics first stage.
Order Processing	Necessary actions considered to ensure production flow continuity, performed after customer request.
Warehousing	Activities assigned to manage the warehouse space required to store the inventory.
Communication	Being considered as the "vital link between the entire logistics process", communication guarantees the equal information sharing across the supply chain, without being at the same place.

Among these 6 logistics activities, warehousing management is going to be developed in the next section, detailing the typologies and the main operations performed inside the warehouses.

2.2 Warehousing Management

Warehousing activity is responsible for the storage of all types of goods (raw materials, parts, goods-in-process, finished goods), simplifying their movement from the very first supplier to the player the product is being produced for (Vonderembse and White, 1996; Stock and Lambert, 2001; Rushton *et al.*, 2010).

This logistics activity, in most of the cases, does not add any value to the final customer by itself, despite being essential to the whole chain (Tompkins and Smith, 1998; Christopher, 2016; Carvalho *et al.*, 2018). As Ballou mentions (2004: 470), "storage become an economic convenience rather than a necessity". Warehousing activities help companies managing their gap between supply and demand, decreasing supply chain vulnerability and decoupling demand from production capabilities (Ballou, 2004; Rushton *et al.*, 2010; Bartholdi and Hackman, 2017; Carvalho *et al.*, 2018). Once production and consumption occur in different places, the closer the product is to the final customer, the better (Carvalho *et al.*, 2018). In some cases (e.g. wines, cheeses), products need a holding stage to be completed, a place where they can be kept during the transformation phase. The warehouse appears in this scenario as that place that holds the products, adding in this case valued attributes to the products (Ballou, 2004). Based on this, inventory is seen, not only as a company asset, but also as a dangerous variable expense that requires an effective control system in order to lead to success (Coyle *et al.*, 2012).

Among the literature, there are several reasons that justify the fact that companies have stock held in their warehouses. Some authors defended that stock should be held so it will be possible to achieve economies of scale, by producing-to-stock, always keeping the production line supplied, and getting quantity discounts through high volumes of bought products (Coyle *et al.* 1992; Vonderembse and White, 1996; Stock and Lambert, 2001; Ballou, 2004; Rushton *et al.*, 2010; Coyle *et al.*, 2012). Safety stock is also mentioned as a reason that justifies holding stock, since it helps minimizing supply or demand uncertainties and avoiding stock-outs (Coyle *et al.*, 1992; Vonderembse and White, 1996; Rushton *et al.*, 2010; Coyle *et al.*, 2012). Stock can be also used to place the products

closer to the final customer, absorbing demand oscillations and, consequently, better quality service (Vonderembse and White, 1996; Stock and Lambert, 2001; Ballou, 2004). Holding stock is considered an advantage when it is used to support the production line, when the production lead time is longer than the client order lead time, and to prevent the seasonal effect that some companies may have (Coyle *et al*., 1992; Rushton *et al*, 2010; Coyle *et al.*, 2012).

It does not matter how the products are stored, or the reason why companies do it, but once the products are stored, they need to be handled carefully, always attempting to minimize the internal costs.

2.2.1 Warehouse Typologies

When it is time to choose which layout a company should implement, it is important to remember that it must be planned to minimize the travel distance and facilitating internal flows (Bowersox *et al.*, 2002; Carvalho *et al.*, 2018).

The layout typology can be classified based on the products flow inside a warehouse, in which the two most used are Directional or Flow-through and Broken or U-flow (Carvalho, 1996) (see Fig. 2). If the receiving and shipping areas are located on opposite sides, products follow a directional or flow-through configuration. The other classification is when receiving and shipping areas are adjacent to each other, making the products go in and out on the same side of the warehouse (Rushton *et al.*, 2010; Bartholdi and Hackman, 2017; Carvalho *et al.*, 2018). Companies also have other options, such as the L-flow in which the receiving and shipping area are not located side by side, neither in opposite sides, or a mixture between these three typologies (Rushton *et al.*, 2010).

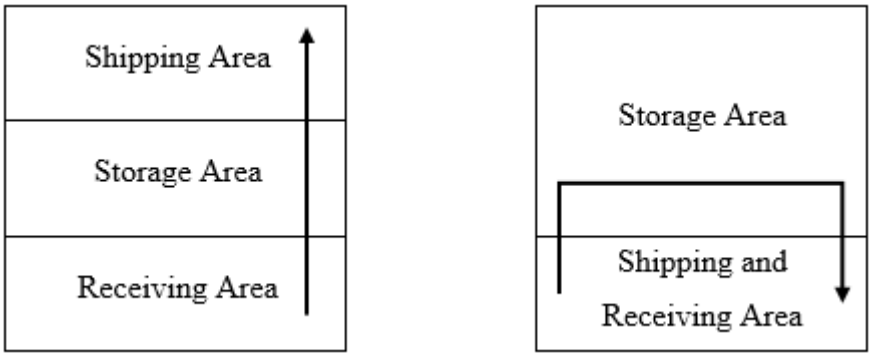


Fig. 2 - Flow-through (in the left) and U-Flow (in the right) Typologies (Adapted from Carvalho et al., 2018)

Concerning flow-through, managers can take some advantage by using this typology because it reduces the travelling time inside the warehouse, as well decreases the traffic and internal congestion because the receiving and shipping area are on opposite sides (Carvalho, 1996; Carvalho *et al.*, 2018). When a company decides to adopt the U-flow, average travelled distance is reduced, the space allocated to the reception and shipping areas decreases (since it is at the same place), and it is indicated for a better storage allocation (Carvalho, 1996; Carvalho *et al.*, 2018).

No matter which layout typology a company implements, all warehouses have the same overall main internal functions. The following subchapter presents and describes each of them.

2.2.2 Warehouse Operations

Each warehouse has its own internal activities. However, all of them have the same four main functions (Tompkins and Smith, 1998; Bowersox *et al.*, 2002; Rushton *et al.*, 2010; Bartholdi and Hackman, 2017; Carvalho *et al.*, 2018): *Receiving* the product from a certain source; *Storage* them until the moment they are needed; at that time, *Picking* them to satisfy an order and *Shipping* the products to the user that requested them.

- Receiving

Associated to this function, it is the confirmation process. Every time a warehouse receives a product to store, picker needs to confirm that everything is in accordance with the agreed. Carvalho *et al.* (2018) referred that reception and checking may consist in seven steps: planning the receptions orders, the arrival of the vehicle, unloading process, checking its cargo, palletizing it (depending on the product characteristics), stablishing a storage location and update the stock in the system.

- Storage

After assigning a location to the new product, it is time to store it. According to Hausman *et al.* (1976), there are three ways to do it: first, attributing a fixed/dedicated location to each product, and it can only be stored in that place; second, every product is

randomly stored in empty places during the reception period, leading to a higher average travel time (Glock and Grosse, 2012); and lastly, class-based location, characterized by different storage zones, where each product has a single associated area, yet randomly stored inside it. These three storage techniques will be further developed in sub-chapter 2.3.2.

Regardless of the technique implemented, companies still have to choose between several storage system options. According to Carvalho et al. (2018), these systems can be divided into manual and automatic. In terms of manual options, it is possible to find the conventional rack, in which the palletized products are stored on regular shelves, allowing the unitary and direct access to each reference. This system is indicated for warehouses that have a big amount of references. Another option is Drive-in/through rack, which also stores palletized products, yet with far fewer references to store, attempting to equalize the number of shelves with the references. Cantilever rack is a structure that holds bulky cargos which are difficult to store on regular shelves due to the products' shape. The last manual system is the gravitational rack. This time, the references are stored at one end and, through gravitational force and a rolling platform, they slide to the opposite end.

In the automatic storage systems, it is possible to identify the vertical and horizontal carousels and the self-supporting warehouses. The first one (sometimes called as Kardex), is a vertical or horizontal structure that makes the references come to a single point by the shelves' movement. It is indicated for references with small dimensions. Self-supporting warehouse works as a Kardex but for bigger references. Contrary to the previous, the whole infrastructure where the warehouse is in, is only used for this purpose. The entire storage mechanism is automatic where the cargo is moved aided by elevators computer controlled and not by the shelves' movement as the Kardex. This type of system is usually used for references with big dimensions.

- Picking

After the product being stored, it is ready to be picked. An order request is issued by the customer and all the service process begins. Hall (1993: 76) defined picking as the one "which items are retrieved from stocking locations in a warehouse." Besides that, Carvalho *et al.* (2018: 308) says that picking activity has a direct impact in the logistics triangle in which "the faster the picking, the quicker the customer delivery (Time); the

more efficient the picking, the lower the cost to the customer (Cost); and the more effective the picking (without errors), the higher the service quality".

Tompkins and Smith (1998) argued that order picking is considered, by warehouse professionals, as the most critical function in their distribution operations. For this reason, the strategy adopted needs to be carefully designed. Depending on that choice, picking can be performed in four different ways (Van den Berg and Zijm, 1999; Tompkins and Smith, 1998; Ballou, 2004; Rushton *et al.*, 2010; Carvalho *et al.*, 2018).

1. *Picking by Order* – Guided by an order list, picker has the responsibility to collect every item from it. Orders are not mixed in the same list.
2. *Picking by Line* – In this method, picker collects the quantity to satisfy several orders at the same time, from each location.
3. *Zone Picking* – Warehouses are divided into areas and the picker collects all the items stored per zone, changing after collecting all the products from that zone.
4. *Batch Picking* – A few numbers of orders are assigned to one single picker, who is responsible for collecting all the products from these order lists. The procedure is repeated after finishing the current lists.

Picking by order is more appropriate when each order has many lines to pick (Carvalho *et al.*, 2018). Although it is the simplest picking strategy when the picking is paper-based, this method offers to the companies the solution with the lower probability of error. However, the productivity is the lowest one, due to the time picker needs to complete an order (Tompkins and Smith, 1998; Carvalho *et al.*, 2018). When the performance is analysed per client, this method provides the quicker response, even though it is considered the one that spends the most time travelling (Tompkins and Smith, 1998; Rushton *et al.*, 2010).

When companies decide to use picking by line, the number of picking errors will increase, maintaining productivity levels high (Carvalho *et al*., 2018). According to the same authors, this method requires some special attention when is being performed because products need to be separated for all the orders, after the collection. For that reason, it is the advisable method when companies have few lines to pick (Carvalho *et al.*, 2018).

Resembling picking by order, is zone picking. It is most likely to be used when companies operate different systems and equipment inside the same warehouse

(Tompkins and Smith, 1998; Carvalho *et al.*, 2018), when the orders are usually too big for a single picker (Rushton *et al.*, 2010), or if there is any justification for the physical storage segregation (Rushton *et al.*, 2010). Thus, if companies implement zone picking, pickers are allocated to a specific system, increasing the number of picking errors, towards picking by line, yet showing higher productivity, but with a lower number of errors when compared to picking by order (Carvalho *et al.*, 2018).

The same way zone picking is for picking by order, batch picking is for picking by line (Carvalho *et al.*, 2018). The difference between these last two types is the number of orders picked at once. Whereas picking by line collects every product from the list, in the batch picking mode picker should only select one to four lines to pick at once (Carvalho *et al.*, 2018; Tompkins and Smith, 1998). If companies decide to select this method, the error margin will decrease, since each picker is dealing with a small number of lines (Carvalho *et al.*, 2018). Thus, "the higher the number of orders in each group, the greater the productivity, but also the greater the possibility of error" (Carvalho *et al*, 2018: pp. 310). Rushton *et al.* (2010) argued that companies can benefit in terms of travelling time with this method.

In order to select the best picking strategy, companies must consider some factors that have influence on the picking performance. According to Rushton *et al.* (2010), the product range, the order size, and the equipment used by the picker to collect them are examples of these factors.

- Shipping

In order to finish the warehouse activities, after picking all orders, they need to be properly prepared and marshalled, to be ready for expedition. Knowing that each product has its own packaging requirements, they are packed and put in line in the waiting area, waiting for the arrival of the mean of transportation.

According to De Koster and Van der Poort (1998), Van den Berg and Zijm (1999), De Koster *et al.* (2007) and Tompkins *et al.* (2010), Drury (1988) concluded that about 55% of the total costs inside a warehouse is associated to the picking process. The same research allocated 10% and 15% of the warehousing costs to the Receiving and Storage processes, respectively, and 20% to the Shipping processes. This information is

useful to understand the impact that Picking has on the warehouse costs, meaning that a small improvement can lead to changes of great value.

A few years later, Tompkins *et al.* (2010) uncovered the time proportion associated to each picking activity. They concluded that 10% is assigned to setup the order list, 20% searching the products, and 15% to pick them, whereas 50% of the time is used to travel between shelves and across aisles. Bartholdi and Hackman (2017) reinforce this discrepancy saying that travel is pure waste, increasing labour costs and adding no value to the process. Charts in the Figs. 3 and 4 show these studies' conclusions.

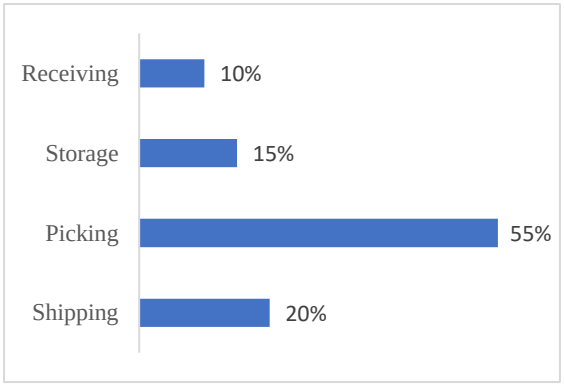


Fig. 3 - Typical Distribution of Warehouse Operating Expenses, Source: Adapted from Drury (1988)

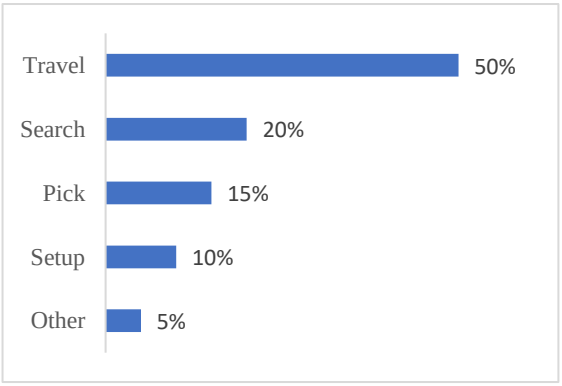


Fig. 4 - Typical Distribution of an Order Picker's Time, Source: Adapted from Tompkins et al. (2010)

Based on these conclusions, even if a small improvement is implemented, the impact will be felt due to the high representativity of the picking process in the total costs (55%). Moreover, the investigation conducted by Tompkins et al. (2010) allowed to identify the key picking related task that should be improved so as to reduce the time spent in the global picking process.

This project moves on describing the picking process, detailing picking route policies and storage assignment strategies most used by companies.

2.3 Picking and Storage Processes

In order to control this sensitive activity, companies usually use picking routes policies and storage product strategies (De Koster *et al.*, 2007; Roodbergen *et al.*, 2008; Çelk and Süral, 2014).

2.3.1 Routing Policies

According to Hall (1993), *Traversal*, *Mid-Point* and *Largest Gap Return Strategy* are described as the three basic routes used inside a warehouse:

- *Traversal Strategy* – In this method, the picker enters at one side of the aisle, crossing it, and exits on the opposite side.
- *Mid-Point Strategy* – Here, the picker enters on an aisle and picks all the products from one side until the exact middle point. When the picker reaches that point, s/he returns, picking the other side of the aisle, exiting from the same side s/he entered.
- *Largest Gap Return Strategy* – This happens when picker enters and exits on the same entry point, but the return point is not the exact middle point.

When these basic routes are individually compared, Hall (1993) describes the traversal strategy as the simplest strategy, due to its ease with which the route is drawn. In addition, Goetschalckx and Ratliff (1988) argued that it is significantly better to use traversal policy in every aisle, rather than the return (or mid-point, in Hall's language) strategy. Manzini *et al.* (2007) studied the impact of several variables on the picking cycle time and concluded that the return (or mid-point, in Hall's language) is the best strategy when it comes to a quadratic warehouse, and traversal when a company operates in a rectangular one.

Companies might have some issues in trying to find the best route for their order pickings. However, De Koster and Van Der Poort (1998) and Roodbergen and De Koster (2001a) argued that this problem may be simply solved by using a heuristic, known as S-shape. It consists in moving across aisles in S-shape curves, while products are being picked (De Koster and Van Der Poort, 1998; Roodbergen & De Koster, 2001a). It is basically a traversal strategy, where the picker does not need to cross an aisle if there is no picking to do (De Koster et al., 2007; Çelk and Süral, 2014).

This procedure can be used by some companies due to its simplicity, but the real savings arise when companies select an optimal algorithm as a picking method (De Koster and Van der Poort, 1998). For that, according to Goetschalckx and Ratliff (1988), Jarvis and McDowell (1991), Cormier and Gunn (1992), Roodbergen and De Koster (2001b)

and Bartholdi and Hackman (2017), Ratliff and Rosenthal (1983) have suggested a solution that minimizes distance and/or time travelled inside a warehouse.

In accordance with Ratliff and Rosenthal (1983), the procedure to construct the algorithm is as follows: guided by the order list, the first step is to select the closest shelf to the entry point, with this representing the beginning of the route. After picking that product, a second shelf must be chosen. This shelf should be the one closest to the shelf that was initially selected. The order picker should follow this procedure until the order list is completed.

2.3.2 Storage Assignment

After receiving the products from the suppliers (or from the plant itself), there is "a set of rules which can be used to assign products to storage locations" (De Koster *et al.*, 2007: 488). This process is mentioned as "Storage Assignment" in the literature in the area.

Yet there are several different ways to associate a location to a reference, literature identifies three basic types (Hausman *et al.*, 1976; Petersen and Aase, 2004; De Koster et al, 2007; Chan and Chan, 2011; Carvalho et al., 2018):

- Randomly Storage – References are stored in any available space where the product can fit at the storage moment.
- Fixed or Dedicated – An exact location is associated to the references, and they have their own location and cannot be stored in any other.
- Class-based Location – Being a mixture of random and fixed storage, the warehouse is divided into zones/areas and each product is associated with one single zone/area and cannot be stored in any other location. Inside each area, products are randomly stored, depending on the available space.

Even though it is considered as the most used due to its simplicity, Random Storage approach depends on a computer to control the operation, once a product's location changes every time it is stored (De Koster *et al*, 2007; Carvalho *et al*., 2018). Besides that, in order not to lose the track of the products, the computer system needs to be constantly updated (Carvalho *et al*., 2018). With this storage assignment, picker needs to travel a greater distance to do the same picking list (Stock and Lambert, 2001; Carvalho

et al., 2018) if products have different rotation levels. On the other hand, the space utilization is more efficient due to the possibility to use any available space in the warehouse (Stock and Lambert, 2001; Carvalho *et al*., 2018).

When products have a fixed location, the major disadvantage, contrary to the random, is the low utilization of space, once companies must keep the space available for the products' maximum stock, even when the product is out of stock (De Koster *et al*, 2007; Carvalho *et al*., 2018). However, companies do not need to worry about increasing the warehouse dimensions because they were designed to store every reference, at its maximum stock level (Carvalho *et al.*, 2018). Another advantage is the fact that order pickers, after repeating the process repeatedly, they begin to know where the references are stored, making the search procedures easier (De Koster *et al*, 2007).

Finally, class-based location appeared to try to combine the advantages of the two previous methods (Chan and Chan, 2011; Carvalho et al., 2018). Rao and Adil (2013) argued that this method may increase the warehouse's performance up to 40%, when compared to the random storage. Nevertheless, the distances travelled can also be reduced in this method, since the products with greater turnover are stored closer to the entry point, making the most frequent trips shorter (Chan and Chan, 2011).

Based on Pareto's research, about wealth issues around the world (Carvalho, 1996; Tompkins and Smith, 1998), ABC analysis purposes a storage solution, by dividing the products into three distinct classes – A, B, and C. The first one, considered as the most sensitive, owns 20% of the total products, representing 80% of the total sales, operational cost, volume, picking frequency or other characteristic, depending on the criterion selected as the most relevant for such classification. Since these products are very valuable when compared to the others, their location inside the warehouse must be at the nearest aisle to the entry point. Thus, the picker collects value products as close as possible from the entry point, decreasing the travelled distance, caused by the high picking frequency. Group B is responsible for 30% of the total products, representing 15% of the chosen criterion. Due to their medium relevance, products within this group should be stored in the middle of the warehouse, right after the group A. Behind them, the area is reserved for group C (not that relevant products), which holds the remaining 50% of the total products, assuming 5% of the criterion (Jarvis and McDowell, 1991; Carvalho, 1996; Vonderembse and White, 1996; Tompkins and Smith, 1998; Stock and

Lambert, 2001; Rushton *et al.*, 2010; Bartholdi and Hackman, 2017; Carvalho *et al.*, 2018).

The criteria to segregate the products into these three categories varies according to the main goal of the analysis. Whereas Onwubolu and Dube (2006) have chosen operational costs, Balaji and Kumar (2014) refer weight and product shape, Vonderembse and White (1996) use annual dollar usage value, Carvalho (1996) and Dutta *et al.* (2017) considered annual revenue, whereas Carvalho *et al.* (2018) and Bartholdi and Hackman (2017) did the analysis using the sales volume as the main criterion to segregate the products.

2.4 Conclusion

This previous chapter allowed (1) to define and develop the theoretical concepts in a general way, clarifying the basis warehousing management; and (2) the selection of the best practices that the literature recognizes as the most indicated when it comes to improving routes during the picking process.

Managers have been striving for finding the best route inside the warehouse during the picking process a couple of decades. For this reason, it is possible to conclude that all the studies done so far have created the needed theoretical basis to guide this project in the right direction.

Literature review allowed the perception that the picking processes may have a huge impact on warehousing costs. However, there is also several ways to improve them, making them more efficient.

By simulating several scenarios, combining picking routes along with storage allocations, this project attempts to study the impact of these alternative scenarios in the total travelling distance in the picking process.

3 The Company: LAUAK Portugal

Groupe LAUAK is a French group that owns a set of industrial companies which supplies the aeronautical market. Having begun its activity in 1975 by producing small sheet metal parts in France, it has been expanding their business through assembly of heat exchanges, fuel tanks and aircraft structures over 25 years. Nowadays, the group owns 7 plants over France, Portugal, Mexico and Canada, employing about 1500 people.

In 2003, the group opened a plant in Portugal responsible for transforming metal sheet in a wide range of aircraft components. Apart from these individual parts, LAUAK Portugal is also specialized in assembling structures for a specific range of aircrafts. Among them are Fuel Tanks (for Dassault F7X, T3 and T4 Falcon 900), Cockpit Layout (for Airbus A320 and A350), and Cargo Door Frame (for Airbus A320), either for domestic or foreign customers. On this list are Airbus, Embraer, Ogma, Dassault, Daher, and Liebherr. Counting with more than 650 employees working in this plant, LAUAK Portugal is accredited by ISO 9001, 9100 and 14001, and by Nadcap in the fields of surface treatment, non-destructive quality controls, heat treatment, and welding processes.

The next two subchapters describe the final product warehouse's layout under investigation and the respective internal processes.

3.1 Warehouses

LAUAK Portugal owns four warehouses: two for raw material (thin and thick), one for work-in-process and another for the final products. The final product warehouse was selected for analysis in this project because the company considered that the picking process was taking longer than desired, delaying all sales and transportation procedures downstream. It only stores small aircraft components, ready to be sent to the final customers.

This warehouse, with almost 100 square meters (12,78 x 7,62 meters), has three horizontal aisles (hereafter referred to as A1 [Bottom Aisle], A2 [Middle Aisle], and A3 [Top Aisle]), and it is disposed in 44 shelves. It follows a U-flow configuration, being divided into three product families:

- *FAI*: prototypes waiting for quality approval to be shipped to the customer;
- *ESKU*: products belonging to a partner factory of the group;
- *PFBE*: finished products, owned by LAUAK Portugal, being considered the most relevant family inside this warehouse.

The warehouse layout, designed in centimetres, is represented in figure 5.

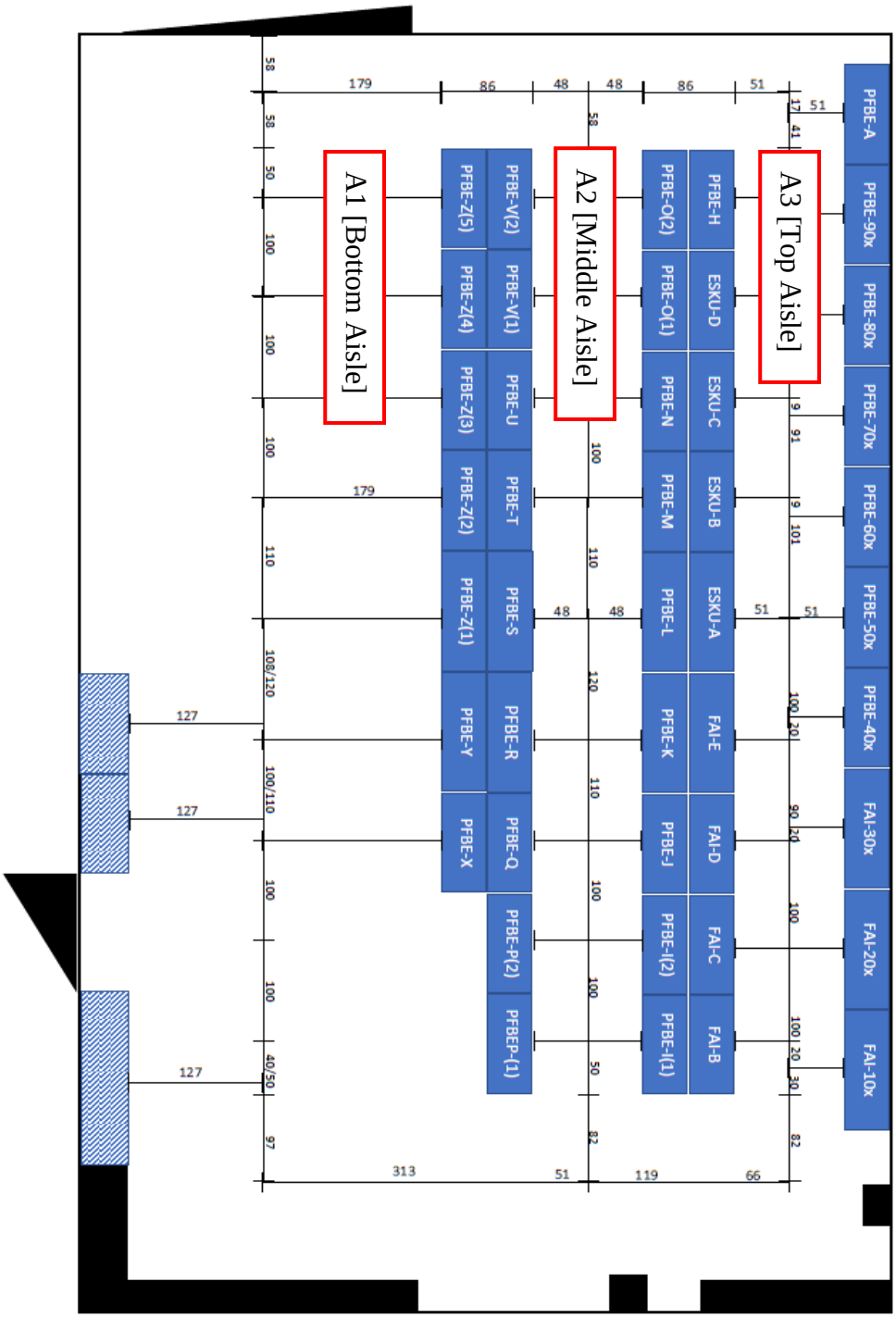


Fig. 5 - Final Product Warehouse's Layout

3.2 Warehouse Processes Description

Finishing the manufacturing processes, all the products pass through a final quality control phase. After being declared as suitable for selling, they are moved to the following section – Sales. There, if a sales order had been already issued, the products are sold and continue to the packaging section, going straight to the shipping waiting area, right after that. Otherwise, after the selling and packaging activities, they need to be stored until a selling order is issued.

When the products need to wait for a new selling order, it is assigned a family section (FAI, ESKU, or PFBE) so they can be stored in the right place. Regardless on the product family, products are randomly stored on the shelves that are dedicated to its particular family. There are different boxes on the shelves to accommodate small and medium size products. Large items are freely placed on the shelves itself.

Picker generates everyday an order list containing the products that have an issued order request. This list is structured according to the delivery date, which means that the first product that appears on the list is the product that needs to be delivered first. Random is the storage assignment adopted by the company and there is no picking route pre-stablished.

4 Methodology

It is intended with this chapter the presentation and description of the project's methodology. Beginning with the methodology approach selected, the steps taken to reach the main goal are then clarified and justified.

4.1 Methodology Approach

According to Yin (2018), three conditions must be verified to characterize a research method as a case study. According to this author, researchers should use a case study's methodology when:

1. A "how" or "why" question is answered;
2. The event under investigation cannot be manipulated by the researcher;
3. The research must attempt to solve a contemporary and real-life problem;

Based on these three conditions, the methodology adopted in this project complies with the guidance of a case study, and it is structured following the recommendations purposed by Voss et al. (2002) and Yin (2018).

Yin (2018) argues that a case study can be used for three purposes: exploratory, descriptive, or explanatory studies. Once this project describes a real-world context phenomenon and can be used in other investigations to study similar problems, the purpose of this project is exploratory and descriptive. Besides that, this study can be classified as a single case due to the fact that the environment under investigation only represents one business situation, not taking into account other companies' influences.

4.2 Case Study's Stages

This project was developed following several consecutive research steps, as mentioned in Figure 6.

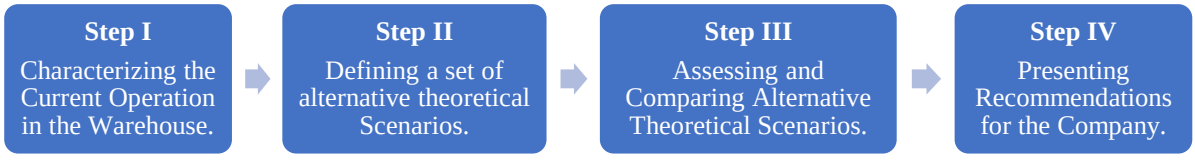


Fig. 6 - Research Steps

4.2.1 Step I – Characterizing the Current Operation in the Warehouse.

Characterizing the current operation in the LAUAK's final products warehouse requires the use of several sources of information. Particularly, four sources were used to ensure the detailed and accurate data collection of both qualitative and quantitative information (Yin, 2018): documentation, archival records, informal interviews, and direct and participant observation.

Qualitative Data

To collect qualitative data, one crucial source in a case study environment are unstructured interviews (Yin, 2018). Different company's employees, in different hierarchical roles, were selected to ensure the information veracity, enabling the full understanding of the internal processes (Voss *et al.,* 2002). The Head of Logistics, the Warehouse Picker, and the Warehouse Manager were the main stakeholder in this data collecting process. Direct observation and official documents were other sources used in the qualitative data collection.

To start this data collection process, it was created a script (Appendix A), acting as a supportive tool to the unstructured interviews.

The project's specifications were initially explained by the Head of Logistics, as well as all the requirements and desired milestones. Afterwards, a visit to the factory was also carried out, where it was possible to superficially understand the processes of the whole plant and visualize the respective connection and flows between them.

Following this first contact with the company, the warehouse process description was presented by the picker. Aiming at achieving a detailed mapping of the process, informal questions related to the daily tasks have been asked, such as the way other sections interact with the final product warehouse and the tasks' sequence performed on a daily basis. Other subject addressed in the interview, and very important to the analysis, was the layout adopted by the company for both the warehouse itself and the shelfs' sequential order.

The warehouse manager was also interviewed, this time attempting to clarify more specific points. For a better understanding of the company strategy, questions concerning the warehouse improvements, implemented over the past years, were also asked. The

warehouse manager explained the storage assignment strategy used by the company, mentioning restrictions that might exist.

At a higher decision level, the Head of Logistics was interviewed once again, this time to understand tactical choices the company had made. The objective was to clarify the reason why the company was using the random storage strategy and a non-defined picking route.

Content reliability and validation can be increased when multiple sources are used to investigate the same environment, being this designated as *Triangulation* (Eisenhardt, 1989; Voss *et al.*, 2002; Yin, 2018). Thus, after concluding this methodological stage, it was decided to see in the field, by direct observation, what had been addressed in the interviews (Yin, 2018). At the same time the picker was being interviewed, movements of products inside the warehouse were followed daily for one and a half weeks. The storage and picking processes were meticulously monitoring to guarantee that all the required information to characterize the internal processes had been collected.

Thought participant-observation (Yin, 2018), storage and picking activities were performed, in their totality, during three days for a better understanding and to ensure the information validation.

Quantitative Data

To gather the quantitative data, it was used other three different sources (Yin, 2018): archival records, direct and participant observation.

Once it is attempted to decrease the travelled distance inside the warehouse during the picking process, the distances between and across aisles and shelves needed to be measured. As no information existed concerning these distances, the warehouse was measured using participant-observation. This action also allowed the creation of the warehouse's layout representation (Fig. 5).

After knowing these measures, picking routes calculations could be initiated. Picker's performance was tracked through direct-observation for one month, being considered the reference scenario in this analysis (hereafter referred to as Scenario 0). It is considered in this scenario the current daily operations in the warehouse, either for picking route or storage assignment.

This period, September to be exact, was considered by the company a standard month, representing the overall operations over the year. During this period, every picked

item, as well the respective movements to reach them, were closely followed and registered.

Another data needed in this analysis are the products and shelves' volumes and the daily stock. As the company did not have any information concerning the products and shelves' volumes, the data was collected in the field by participant-observation, in the field. To calculate the product average stock, a monthly basis analysis was carried out where the everyday stock was extracted directly from the company's ERP. Yin (2018) designates this way of data collection as "Archival Records".

4.2.2 Step II – Defining a Set of Alternative Theoretical Scenarios

After collecting all the needed information to proceed with the analysis, several alternative theoretical scenarios were selected and defined, considering different picking routes policies and storage assignment strategies.

Picking Routes

According to Hall (1993), Traversal, Mid-Point, and Largest Gap Return strategies are the three basic picking routes (PR) performed inside a warehouse. When these three basic routes are combined, 21 different picking routes are created. For a better understanding, a graphical representation can be found on the appendix's chapter (Appendix B to Appendix V).

In this analysis, apart from these 21 PR, Ratliff and Rosenthal (1983) created a heuristic, which is often mentioned as one that offers an optimal picking route, minimizing the travelled distances inside the warehouse (Goetschalckx and Ratliff, 1988; Jarvis and McDowell, 1991; Cormier and Gunn, 1992; Roodbergen and De Koster, 2001b; Bartholdi and Hackman, 2017). The algorithm published by these authors was also used, creating the 22nd picking route in this research. S-Shape Curves strategy is not specified in this analysis because it is equivalent to the Transversal strategy in this specific warehouse.

Combining all the basic picking routes route and the heuristic, 22 PR were considered in this case study, as summarized in Table 2.

Table 2 - Selected Picking Routes

Picking routes	Number of routes	Strategy
PR-1 to PR-18	18	Largest Gap Return Strategy in one aisle and Transversal in the other two, changing the aisle in which the route is started (6 scenarios starting in aisle A_1, 6 scenarios starting in aisle A_2 and 6 scenarios starting in aisle A_3).
PR-19	1	Largest Gap Return Strategy in every aisle.
PR-20 & PR-21	2	Middle-Point strategy in one aisle (A_2 or A_3) and transversal in the other two.
PR-22	1	The algorithm proposed by Ratliff and Rosenthal (1983).

The reason behind the selection of these picking routes was the attempt to analyse the difference between a basic picking route performance and an optimal heuristic, as also studied by Roodbergen and De Koster (2001b). In this case, the 3 basic picking routes are suggested by Hall (1993) and the optimal heuristics by Ratliff and Rosenthal (1983).

Storage Assignment Strategies

Hausman *et al.* (1976), De Koster *et al.*, (2007), Chan and Chan (2011), Glock and Grosse (2012), and Carvalho *et al.*, (2018) identified Random, Class-Based, and Fixed/Dedicated as the three most used storage assignment strategies in companies nowadays (hereafter to as SA – 1, SA – 2, and SA – 3, respectively).

Class-Based (SA-2) and Fixed/Dedicated (SA-3) Storage Assignments will be considered using ABC analysis as a basis to classify each product, considering as criterion the picking frequency during Scenario 0 (real picking/storage movements performed by the picker). It was decided to select ABC analysis because it is one of the most used methods when it comes to storage allocation, as concluded from Chapter 2.3.2 (Le-Duc and De Koster, 2005; Chan and Chan, 2011).

The 22 picking routes (PR) and the 3 storage allocations (SA) considered should be compared with the Scenario 0, which is characterized by a specific warehouse layout, storage assignment and picking route, according to current daily operation in the warehouse.

4.2.3 Step III – Assessing and Comparing Alternative Theoretical Scenarios.

In this methodological step, all the studied scenarios are going to be assessed and compared in terms of the total travelled distance inside the warehouse during the picking activity and compared with Scenario 0.

Based on Roodbergen *et al*. (2008) and Carvalho *et al*. (2018), to calculate these distances, the following Equation (1) should be used:

$$\sum_{i=1}^{n} \sum_{j=1}^{n} D_{ij} * T_{ij} \quad (1)$$

in which *n* represents the number of visited shelves plus one (to include the entrance), *i* and *j* represents a location point inside the warehouse (it can be the entrance or a shelf), D_{ij} represents the distance between a location point *i* and *j* (with $i \neq j$), and T_{ij} represents the frequency in which the distance between location point *i* and *j* is travelled.

4.2.4 Step IV – Presenting Recommendations for the Company.

According to Voss *et al*. (2002), a case study is only completed when the results obtained are shared with the companies' superior boards, looking for company's validation. In this case, the feedback was gotten after their presentation in an informal meeting to the Head of Logistics.

5 Case Study

Chapter five will be used to develop the case study. It will be initially detailed the data used in the investigation, specifically (1) distances between and across shelves and aisles, enabling the picking routes (PR) calculations, and (2) shelves and products' volume, in order to implement the ABC analysis. The picking routes (PR) are then presented, as well as the way as all distances were calculated.

The final results are also disclosed in this chapter, discussing separately the performance of each PR in random storage assignment and class-based, giving a global comparison after that.

5.1 Defining a Set of Alternative Theoretical Scenarios

5.1.1 Data Details

The way the data was collected was already addressed in the methodological chapter. It is also important, before moving forward, to highlight the details behind that data.

In order to assess the alternative scenarios, an EXCEL Tool was developed to automatically calculate the travelled distances. Working as a simulator, a symmetric table was designed, containing the distances between each shelf to all the other shelves in the warehouse, originating a matrix with 2025 cells. The Table 3 represents an example of that matrix, being possible to find the full matrix in the Appendix W.

Table 3 - Distances Matrix (Shelves: PFBE – A, PFBE – H, PFBE – I1, PFBE – I2, and PFBE – J)

Rack	Entry	PFBE-A	PFBE-H	PFBE-I1	PFBE-I2	PFBE-J
Entry	-	624	715	1367	1267	1167
PFBE-A	624	-	193	1249	1149	1049
PFBE-H	715	193	-	1340	1240	1140
PFBE-I1	1367	1252	1340	-	196	296
PFBE-I2	1267	1152	1240	196	-	196
PFBE-J	1167	1052	1140	296	196	-

By introducing two points/shelves (representing the beginning and the ending of a certain movement), the tool automatically generates the travelled distances between these two points.

Also crucial for this investigation is the average stock for each SKU. For one month (the same as in Scenario 0), the available stock was monitored every day, allowing the average stock calculation. These values were used to determine the respective volume of each SKU. Meaning that the products' volumes were measured using that average quantity.

Volumes were other data important in this investigation, either for shelves or for products. In order to calculate the volumes, every shelf was visited to register the volume of each SKU stored in there. A table was created where every SKU, the respective location, width, length, height, average stock, and its volume was listed. Table 4 describes an example.

Table 4 - Exemplification of Products Volume

SKU	Location	Width (Cm)	Length (Cm)	Height (Cm)	Average Stock (un)	Volume (Cm^3)
Product 1028	PFBE-40X	2,7	4,3	2,2	4	25,54
Product 2361	ESKU-A	6,3	7,9	2,8	5	139,36

After calculating the total needed space to store all the SKUs, the shelves' volume was also measured, in order to determine the possible available storage space. Six types of storage option were considered, as it is shown on the Table 5. The detailed description is presented in Appendix X.

Table 5 - Types of Storage

Storage Types	Height (Cm)	Width (Cm)	Length (Cm)	Volume (Cm^3)
Big Shelf	28	120	43	144 480
Small Shelf	28	100	43	120 400
Big Shelf (Top Level)	17	120	43	87 720
Small shelf (Top Level)	17	100	43	73 100
Medium Box	18	20	37	13 320
Small Box	14	12,5	28	4 900

5.1.2 Selected Theoretical Scenarios

Currently, the company uses the Random storage allocation strategy in its final products warehouse. For this reason, the 22 PR were initially simulated considering this strategy.

Due to the fact that the company did not see Fixed/Dedicated (SA – 3) as a doable policy, Random (SA – 1) and Class-Based (SA – 2) were the only two Storage Assignment Strategy considered in this analysis. Thus, after simulating the 22 picking routes on SA – 1, the picking routes were simulated once again on SA – 2. This time, assuming a different product reorganization, aiming even better findings.

Table 6 presents a summary on the scenarios under analysis.

Table 6 - Theoretical scenarios under study

		Storage Assignment Strategies	
		SA-1	**SA-2**
Picking routes	**PR-1 to PR-18**	PR-1/SA-1 to PR-18/SA-1	PR-1/SA-2 to PR-18/SA-2
	PR-19	PR-19/SA-1	PR-19/SA-2
	PR-20 & PR-21	PR-20/SA-1 & PR-21/SA-1	PR-20/SA-2 & PR-21/SA-2
	PR-22	PR-22/SA-1	PR-22/SA-2
Total number of theoretical scenarios		22	22
		44	

5.2 Assessing and Comparing Alternative Theoretical Scenarios

5.2.1 Assessing Alternative Theoretical Scenarios

Subchapter 5.2.1 addresses the way picking routes were applied in this analysis, describing how they interacted with the simulator (see chapter 5.1.1). Here, it is also detailed, step by step, the development of the ABC analysis, used in the SA – 2.

5.2.1.1 Picking Routes Application

Each basic PR (from PR – 1 to PR – 21) has its own shelves order. It means that, a shelf flow is listed, depending on the order the aisles are crossed. Each PR will be designed based on the reorganization of the picking list, collected during the Scenario 0 assuming that new flow.

Table 7 represents a picking list from the Scenario 0.

Table 7 - A Picking list from the Scenario 0

Beginning	Ending	Travelled Distance (cm)
Entry	PFBE-Z5	345
PFBE-Z5	PFBE-V1	856
PFBE-V1	PFBE-Z3	1056
PFBE-Z3	PFBE-T	1256
PFBE-T	PFBE-H	800
PFBE-H	PFBE-Z4	1044
PFBE-Z4	PFBE-P2	1596
PFBE-P2	PFBE-50X	1078
PFBE-50X	PFBE-S	1320
PFBE-S	PFBE-Z1	1576
PFBE-Z1	PFBE-O1	1266
PFBE-O1	PFBE-A	512
PFBE-A	PFBE-Z3	1053
PFBE-Z3	PFBE-Z3	-
PFBE-Z3	PFBE-P2	1610
Total		15368

After selecting one PR (from PR – 1 to PR – 21), the respective shelves order is generated, reorganizing the shelves so the new route can be designed.

To exemplify, it will be used PR – 1, which has the following shelves order:

PFBE-Z5 → PFBE-Z4 → PFBE-Z3 → PFBE-Z2 → PFBE-Z1 → PFBE-Y → PFBE-X → PFBE-O2 → PFBE-V2 →PFBE-O1 → PFBE-V1 → PFBE-N → PFBE-U → PFBE-M → PFBE-T → PFBE-L → PFBE-S → PFBE-K → PFBE-R → PFBE-J → PFBE-Q → PFBE-I2 → PFBE-P2 → PFBE-I1 → PFBE-P1 → FAI-10X → FAI-B → FAI-20X → FAI-C → FAI-D → FAI-30X → FAI-E → PFBE-40X → ESKU-A → PFBE-50X → PFBE-60X → ESKU-B → PFBE-70X → ESKU-C → PFBE-80X → ESKU-D → PFBE-90X → PFBE-H → PFBE-A.

By crossing this shelves order (PR – 1) with a picking list (Table 7), the visited shelves are organized according to this new order and the new picking route is created. Table 8 shows this new reorganization:

Table 8 - Application of the PR – 1

New Beginning	New Ending	Order in PR – 1	New Travelled Distance (cm)
Entry	PFBE-Z5	1	345
PFBE-Z5	PFBE-Z4	2	458
PFBE-Z4	PFBE-Z3	3	458
PFBE-Z3	PFBE-Z3	3	-
PFBE-Z3	PFBE-Z3	3	-
PFBE-Z3	PFBE-Z1	5	568
PFBE-Z1	PFBE-O1	10	1266
PFBE-O1	PFBE-V1	11	96
PFBE-V1	PFBE-T	15	296
PFBE-T	PFBE-S	17	206
PFBE-S	PFBE-P2	23	426
PFBE-P2	PFBE-P2	23	-
PFBE-P2	PFBE-50X	35	1078
PFBE-50X	PFBE-H	43	512
PFBE-H	PFBE-A	44	193
PFBE-A	Entry	-	624
Total			6526

In this example, organizing the visited shelves in a different way, the distance travelled decrease immediately 8842 cm, from 15368 cm to 6526 cm.

The procedure is different when it comes to the heuristic (PR – 22). The route is only designed after manually introducing the closest shelf to the entry point that needs to be visited. After selecting that starting point, the system generates a list which ordinates all the other warehouse shelves by the proximity, assuming always the previous visited shelf.

5.2.1.2 ABC Analysis

In this investigation, in order to be able to segregate the products, aiming their reallocation, ABC analysis was considered due to its great use by companies worldwide (Le-Duc and De Koster, 2005; Chan and Chan, 2011).

First, the products were classified according to the families already in use within the warehouse: PFBE, ESKU, or FAI. There are specific areas for each family and, according to company's indications, it is not possible to mix them. Within each family, ABC analysis was used to classify products in A, B, or C, depending on the relevance to the company, using as criterion the picking frequency during the Scenario 0.

Products classified with A, B, or C were the ones presented on the picking list collected during the Scenario 0. Class D included all the other products that did not have any movement during that collection period.

After dividing them into classes, items were further divided into Big, Medium, or Small. The criterion for this assignment was the location where the products were stored during the Scenario 0. In other words, if the product was stored inside a box, the sub-family was "Medium" or "Small", depending on the box's size. If the product was stored on top of a shelf, outside of any box, it was considered as "Big". This classification was also required because the products' size also affected the selection of the shelf where each SKU should be stored.

Considering this segregation, each SKU was classified into families (PFBE, ESKU, or FAI), Classes (A, B, C, or D), and sub-families (Big, Medium, or Small), and ABC Analysis[1] was developed as shown in Tables 9 and 10.

[1] To analyse the full ABC segregation process, see Appendix Y, Z and AA, for PFBE, ESKU, and FAI families, respectively.

Table 9 - ABC Classification

Family	Class	% Products	% Picking Frequency
PFBE	A	18,26%	38,97%
	B	26,33%	29,74%
	C	55,41%	31,29%
ESKU	A	28,00%	31,43%
	B	30,00%	28,57%
	C	42,00%	40,00%
FAI	A	24,82%	60,09%
	B	32,12%	25,23%
	C	43,06%	14,68%

Table 10 - Family, Class, and Sub-Family Segregation

Family	Class	Sub-Families	% Products
PFBE	A	Big	15,71%
		Medium	2,34%
		Small	0,21%
	B	Big	19,53%
		Medium	5,95%
		Small	0,85%
	C	Big	40,13%
		Medium	14,44%
		Small	0,84%
ESKU	A	Medium	24,82%
	B	Medium	32,12%
	C	Medium	43,06%
FAI	A	Big	24%
		Medium	4%
	B	Medium	30%
	C	Medium	42%

This warehouse is divided into three areas, according to the products' families. Due to their relevance, PFBE products (higher turnover) were first allocated to the shelves closer to the warehouse entrance, followed by ESKU products, and FAI products, respectively. Within each family, due to the higher turnover, class A was first reallocated, followed by B, C, and D, respectively, being the closest shelf to the warehouse's door the first shelf to be fulfilled.

Assuming that, PFBE was the only family where the classes were not mixed. Products were allocated to each shelf until 70%[2] of the available space was totally fulfilled. In this case, the next shelf started to be fulfilled with more products from the same class (A, B, C, or D). If a shelf has not been fully filled, but there were no more products from the same class, that space remained empty, being reserved for other products that may be transferred from another family over time.

Inside the space assigned to each class, the products were stored randomly, only respecting the sub-family (Big, Medium, or Small). Meaning that, inside the space reserved for each sub-family, if a product was considered medium or small, it was stored in the respective box. Otherwise, the product was placed on the shelf.

In the ESKU and FAI's cases, due to the lower products quantity, classes (A, B, C, or D) and sub-families (Big, Medium, or Small) were mixed on the same shelf. However, class A was reallocated on the level that has the easier access to the picker.

When a class is completed, the next one is reallocated until every product, sub-family, class, and family is also completed.

Assuming this, the reallocation[3] was designed as shown in Table 11:

Table 11 – Products' Reallocation

Family	Class	Assigned Location
PFBE	Class A	PFBE-Z5
	Class B	PFBE-Z4; PFBE-V2;
	Class C	PFBE-O2; PFBE-Z3; PFBE-V1;
	Class D	PFBE-A; PFBE-O1; PFBE-Z2; PFBE-H; PFBE-90x; PFBE-N; PFBE-U; PFBE-Z1; PFBE-80x; PFBE-M; PFBE-T; PFBE-Y; PFBE-70x; PFBE-L; PFBE-S; PFBE-X;
FAI	Class A / B / C	FAI-E;
	Class D	FAI-30X; FAI-D;
ESKU	Class A/B/C	ESKU-D;
	Class D	ESKU-D; ESKU-C; ESKU-B; ESKU-A;

[2] It was considered that percentage because it is the average portion of space that company is using currently.

[3] To analyse the full product's reallocation process, see Appendix BB, CC and DD, for PFBE, ESKU, and FAI family, respectively.

Figure 7 shows the warehouse layout, organized according to the new structure. “Red” shelves represent the products classified as A; class B is represented in “Yellow”, and C in “Green”. “Blue” shelves store every class D product, from any family.

Finally, “Purple” indicates the shelves that have more than one class inside it (only applied to ESKU and FAI families).

Under a red cross, are represented in “Grey” the 15 shelves that were not used in the new product’s allocation.

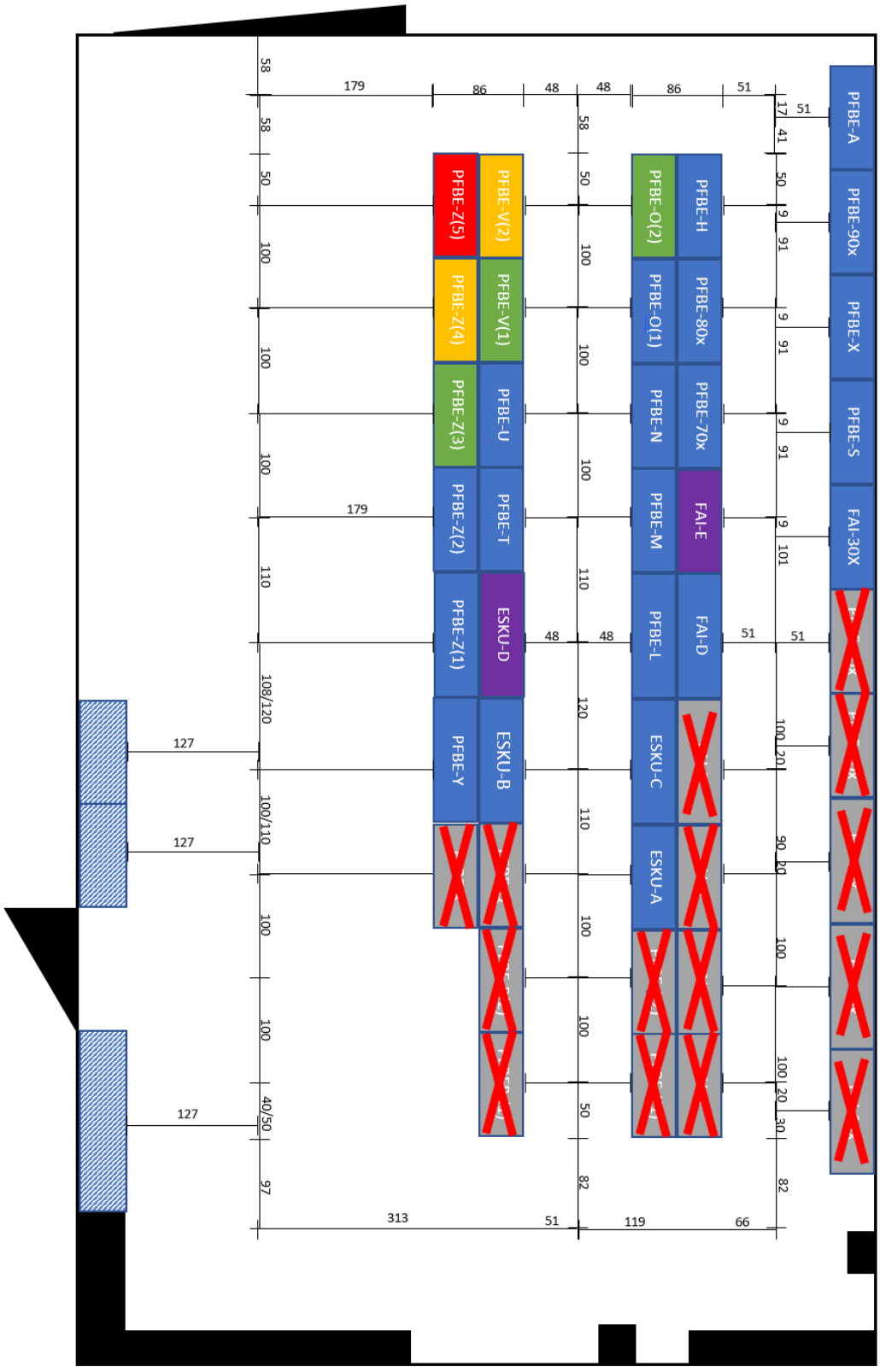


Fig. 7 - New Warehouse's Layout

5.2.2 Travelled Distances per Scenario - Random Storage Strategy (SA - 1)

All the PR were simulated on the already implemented storage strategy (SA – 1: Random), generating the first 22 scenarios (PR – 1/SA – 1 to PR – 22/ SA – 1). The travelled distances in each route, as well as the reduction, compared with the Scenario 0, are listed in the Table 12.

Table 12 - Travelled Distances per Scenario (SA – 1)

Scenarios	Travelled Distances (cm)	Reductions	
		Cm	%
Original (Scenario 0)	604 443	-	-
PR – 1/SA - 1	340 584	- 263 859	-43,65
PR – 2/SA – 1	324 916	- 279 527	-46,25
PR – 3/SA – 1	325 936	- 278 507	-46,08
PR – 4/SA – 1	338 622	- 265 821	-43,98
PR – 5/SA – 1	348 352	- 256 091	-42,37
PR – 6/SA – 1	341 710	- 262 733	-43,47
PR – 7/SA – 1	338 494	- 265 949	-44,00
PR – 8/SA – 1	345 782	- 258 661	-42,79
PR – 9/SA – 1	336 020	- 268 423	-44,41
PR – 10/SA – 1	348 905	- 255 538	-42,28
PR – 11/SA – 1	366 277	- 238 166	-39,40
PR – 12/SA – 1	349 659	- 254 784	-42,15
PR – 13/SA – 1	341 630	- 262 813	-43,48
PR – 14/SA – 1	340 550	- 263 893	-43,66
PR – 15/SA – 1	324 884	- 279 559	-46,25
PR – 16/SA – 1	366 492	- 237 951	-39,37
PR – 17/SA – 1	372 054	- 232 389	-38,45
PR – 18/SA – 1	348 692	- 255 751	-42,31
PR – 19/SA – 1	347 546	- 256 897	-42,50
PR – 20/SA – 1	355 193	- 249 250	-41,24
PR – 21/SA – 1	367 260	- 237 183	-39,24
PR – 22/SA - 1	326 894	- 277 549	-45,92

After calculating all the 22 scenarios, assuming SA – 1, the 22 PR were simulated once again on a new storage strategy: SA – 2.

The simulation was only carried out after the products' reallocation, using ABC analysis, as described in the chapter 5.2.1.2.

5.2.3 Travelled Distances per Scenario - Class-Based Storage Strategy (SA - 2)

In order to calculate whether it is possible to reach a better result or not, picking routes, from PR – 1 to PR – 22, were simulated once again, this time on the new reallocation structure. The method to calculate the distances was the same as the previous one. By using the EXCEL Tool (see chapter 5.1.1), each shelves' order was crossed with the new product location, originating new picking routes.

Table 13 represents the savings reached per PR, when a class-based storage strategy was implemented.

Table 13 - Travelled Distances per Scenario (SA – 2)

Scenarios	**Travelled Distances (cm)**	**Reductions**	
		Cm	**%**
Original (Scenario 0)	604 443	-	-
PR – 1/SA – 2	218 950	- 385 493	- 63,78
PR – 2/SA – 2	218 592	- 385 851	- 63,84
PR – 3/SA – 2	218 204	- 386 239	- 63,90
PR – 4/SA – 2	218 189	- 386 254	- 63,90
PR – 5/SA – 2	218 947	- 385 496	- 63,78
PR – 6/SA – 2	218 189	- 386 254	- 63,90
PR – 7/SA – 2	218 192	- 386 251	- 63,90
PR – 8/SA – 2	218 204	- 386 239	- 63,90
PR – 9/SA – 2	218 192	- 386 251	- 63,90
PR – 10/SA – 2	242 603	- 361 840	- 59,86
PR – 11/SA – 2	242 603	- 361 840	- 59,86
PR – 12/SA – 2	242 603	- 361 840	- 59,86
PR – 13/SA – 2	218 189	- 386 254	- 63,90
PR – 14/SA – 2	218 189	- 386 254	- 63,90
PR – 15/SA – 2	218 189	- 386 254	- 63,90
PR – 16/SA – 2	242 603	- 361 840	- 59,86
PR – 17/SA – 2	242 603	- 361 840	- 59,86
PR – 18/SA – 2	242 603	- 361 840	- 59,86
PR – 19/SA – 2	218 238	- 386 205	- 63,89
PR – 20/SA – 2	218 204	- 386 239	- 63,90
PR – 21/SA – 2	218 223	- 386 220	- 63,90
PR – 22/SA – 2	216 151	- 388 292	- 64,24

5.2.4 Global Comparison

The simple act of implementing a picking route during the picking process originated an immediate decreasing of the travelled distances within the warehouse. In this analysis, all the 22 PR simulated in the Random Storage Strategy (SA – 1), came to prove it.

Even though all of them have decreased the travelled distance, PR – 17 registered the lowest reduction, with 38,45%, compared to Scenario 0. On the other hand, PR – 2 and PR – 15 represented the highest reduction with 46,25%, compared to the same Scenario 0.

Greater results were achieved when a more organized storage strategy was implemented. In fact, each scenario in SA – 2 reached reductions of almost 64%, when compared to the Scenario 0.

Table 14 summarizes the performance of all PR, in both storage assignment strategies, compared to Scenario 0.

Table 14 - Picking Routes' Total Travelled Distance per Storage Assignment Strategy

		Storage Assignment Strategies			
		SA-1: Random Storage		SA-2: Class-based Storage	
		Total travelled distance (cm)	Reduction compared to Scenario 0 (%)	Total travelled distance (cm)	Reduction compared to Scenario 0 (%)
Picking Routes	PR-1	340 584	43,65	218 950	63,78
	PR-2	324 916	46,25	218 592	63,84
	PR-3	325 936	46,08	218 204	63,90
	PR-4	338 622	43,98	218 189	63,90
	PR-5	348 352	42,37	218 947	63,78
	PR-6	341 710	43,47	218 189	63,90
	PR-7	338 494	44,00	218 192	63,90
	PR-8	345 782	42,79	218 204	63,90
	PR-9	336 020	44,41	218 192	63,90
	PR-10	348 905	42,28	242 603	59,86
	PR-11	366 277	39,40	242 603	59,86
	PR-12	349 659	42,15	242 603	59,86
	PR-13	341 630	43,48	218 189	63,90
	PR-14	340 550	43,66	218 189	63,90
	PR-15	324 884	46,25	218 189	63,90
	PR-16	366 492	39,37	242 603	59,86
	PR-17	372 054	38,45	242 603	59,86
	PR-18	348 692	42,31	242 603	59,86
	PR-19	347 546	42,50	218 238	63,89
	PR-20	355 193	41,24	218 204	63,90
	PR-21	367 260	39,24	218 223	63,90
	PR-22	326 894	44,92	216 151	64,24
Scenario 0		604 443 (cm)			

Besides that, it is also possible to verify that there were no significant differences between the PR's, when the storage assignment is Class-Based. Results showed that some PR had the exact same behaviour (e.g. PR – 3, PR – 4, PR – 14, and PR – 15), in a situation where the difference between the lowest and the greatest reduction was only 4,38 percentual points.

When the comparison is made, not with Scenario 0, but between SA – 1 and SA – 2, it is also possible to verify that there were even more significant reductions.

Table 15 shows that difference between scenarios, before (SA – 1) and after (SA – 2) reallocation.

Table 15 - Travelled Distances Calculations Before and After Reallocation

Scenarios	Before Reallocation: SA – 1 (Cm)	After Reallocation: SA – 2 (Cm)	Reductions (SA – 1 vs SA – 2)	
			Cm	%
PR – 1	340 584	218 950	-121 634	-35,71%
PR – 2	324 916	218 592	-106 324	-32,72%
PR – 3	325 936	218 204	-107 732	-33,05%
PR – 4	338 622	218 189	-120 433	-35,57%
PR – 5	348 352	218 947	-129 405	-37,15%
PR – 6	341 710	218 189	-123 521	-36,15%
PR – 7	338 494	218 192	-120 302	-35,54%
PR – 8	345 782	218 204	-127 578	-36,90%
PR – 9	336 020	218 192	-117 828	-35,07%
PR – 10	348 905	242 603	-106 302	-30,47%
PR – 11	366 277	242 603	-123 674	-33,77%
PR – 12	349 659	242 603	-107 056	-30,62%
PR – 13	341 630	218 189	-123 441	-36,13%
PR – 14	340 550	218 189	-122 361	-35,93%
PR – 15	324 884	218 189	-106 695	-32,84%
PR – 16	366 492	242 603	-123 889	-33,80%
PR – 17	372 054	242 603	-129 451	-34,79%
PR – 18	348 692	242 603	-106 089	-30,42%
PR – 19	347 546	218 238	-129 308	-37,21%
PR – 20	355 193	218 204	-136 989	-38,57%
PR – 21	367 260	218 223	-149 037	-40,58%
PR – 22	326 894	216 151	-110 743	-33,88%

Other objective of this study was to compare the performance of a basic picking route combination (PR – 1 to PR – 21) with a heuristic (PR – 22), which is seen as an optimal solution to reduce the travelled distance at its optimal level (Goetschalckx and Ratliff, 1988; Jarvis and McDowell, 1991; Cormier and Gunn, 1992; Roodbergen and De Koster, 2001b; Bartholdi and Hackman, 2017). This analysis concluded that the difference between a basic picking route and the optimal heuristic is not significant, in this specific warehouse. The optimal heuristic showed savings up to 64,24%, 0,34 percentual points above the second-best picking route performance: 63,90%.

It can be added that in the SA – 1 analysis, the PR that had the best performance is not even the heuristic (PR – 22), but a basic picking route combination (PR – 15). The same does not happened on SA – 2. In this case, the best PR was the heuristic, exactly as

the literature predicted (Goetschalckx and Ratliff, 1988; Jarvis and McDowell, 1991; Cormier and Gunn, 1992; Roodbergen and De Koster, 2001b; Bartholdi and Hackman, 2017).

5.3 Recommendations for the Company

It is possible to state that the company is currently using a suboptimal solution and, without any investment, travelled distances inside the warehouse during the picking process can be reduced, and, consequentely, the related costs.

A case study is only concluded when the results are present to the company's superior board, so they can be validated (Voss *et al*., 2002). Based on this, these findings and the main recommendations were presented in an meeting to the LAUAK's head of logistics.

This meeting finished with a very good feedback, saying that this solution fits the company's needs. Attempting to prove the simulation veracity, the company decided to implement one of the best picking routes tested in SA – 1 (PR – 2) one week after the results presentation. The reason behind this choice is because SA – 1 represented the storage assignment currently in use, and thus, it was only needed to implement the picking route to get immediate results.

It was also said that the warehouse location was about to change inside the factory, so the company wanted to repeat this process in the new place, prioritizing the class-based analysis, as simulated in this project. This way, the picking performance in the new warehouse can be improved since the beginning.

6 Conclusion

Lauak Portugal is a partner company of Groupe Lauak, a French group that operates in the aeronautic market. It was within one of its 4 warehouses that this case study was developed. Since the first contact with the Company, there was a specific internal process that was catching the superior's board attention. In the final products' warehouse, the picking process was proving to be critical due to the time it was consuming, considered as excessive by the company, influencing the sales and shipping processes downstream. To achieve the main objective of decreasing this critical process, several scenarios were stablished to assess the picking performance inside the warehouse, mixing picking policies and storage strategies.

Based on the literature, were considered the Traversal, Mid-Point, and Largest Gap Return Strategy (Hall, 1993) as the three basic picking policies and one heuristic (Ratliff and Rosenthal, 1983), as one that offers an optimal solution. Initially, 3 storage assignment strategies were also considered, but following Company's indications, it only remained random (SA – 1) and class-based (SA – 2) storage assignments. In the end, it was created 44 different scenarios of simulation, mixing 22 Picking Routes and 2 Storage Strategies.

The first focus of this case study was getting to know how the warehouse worked, understanding the internal processes, and mapping all the material and information flows. Then, the alternative theoretical scenarios were selected and afterwards simulated, either for picking policies and storage strategy. Considering the travelled distance as variable of analysis, the performance of each scenario was assessed and compared between each of them. This case study ended with the presentation of the conclusions and recommendations towards the superior board.

Considering the warehouse current situation, results showed that only by implementing a picking route, great reductions were achieved. Initially tested in the implemented storage assignment at the time (Random), all 22 picking routes achieved savings between 38,45% and 46,25%, even though no significant differences arose among each picking route. When the products' reallocation was made, Class-based storage strategy was implemented, showing to be more organised than the random alternative. In this case, the reduction was higher than 59% in all the 22 PR.

As the results emerged, it became clearer that the strategy company had selected was far from the optimal, being possible to state that, without any investment, the warehouse efficiency can increase significantly.

Despite the fact this research was developed in a specific business environment, 6 general steps can be adopted by other companies to assess their internal policies and to find more efficient warehousing solutions:

- Step 1 – Creating the Reference Scenario (Scenario 0);
- Step 2 – Selecting the picking routes;
- Step 3 – Simulating the picking routes on the implemented storage assignment;
- Step 4 – Selecting alternative storage assignments;
- Step 5 – Simulating the picking route on the alternative storage assignments;
- Step 6 – Comparing the performance of each theoretical scenario;

A period less than a year was considered in this case study. The period of analysis may lead the research to some limitations, once the full activity was not analysed. A full year investigation would enable more accurate conclusions, taking into account the seasonality or other attributes that might influence the picking frequency. However, in order to soften such impact, the period of analysis was selected to represent, as much as possible, a standard month of the company's overall operations.

To develop even more this research, there are other suggestions that can be considered in future work. Adding more variables to the analysis (products' weight, for instance), increasing the theoretical scenarios, may lead to other visibility over the problem and, hence, the conclusions. A better reallocation could be also purposed if other criteria were included, segregating the product into different families and sub-families.

7 References

Balajia, K., & Kumarb, V. (2014). Multicriteria Inventory ABC Classification in an Automobile Rubber Components Manufacturing Industry. *CIRP, 17*, pp. 463-468.

Ballou, R. (2004). *Business logistics - supply chain management : planning, organizing, and controlling the supply chain* (5th ed.). New Jersey: Pearson Education International.

Bartholdi, J., & Hackman, S. (2017). *Warehouse & Distribution Science.* Atlanta: The Supply Chain & Logistics Institute.

Bowersox, D., Closs, D., & Cooper, M. (2002). *Supply Chain Logistics Management* (1st ed.). New York: McGraw-Hill.

Carvalho, J. (1996). *Logística.* Lisbon: Sílabo.

Carvalho, J., Guedes, A., Arantes, A., Martins, A., Póvoa, A., Luís, C., Dias, E., Dias, J., Menezes, J., Ferreira, L., Carvalho, M., Oliveire, R., Azevedo, S., Ramos, T. (2018). *Logística e Gestão da Cadeia de Abastecimento* (2nd ed.). Lisbon: Sílabo.

Çelk, M., & Süral, H. (2014). Order picking under random and turnover-based storage policies in fishbone aisle warehouses. *IIE Transactions, 46*(3), pp. 283-300.

Chan, F., & Chan, H. (2011). Improving the productivity of order picking of a manual-pick and multi-level rack distribution warehouse through the implementation of class-based storage. *Expert Systems with Applications, 38*, pp. 2686–2700.

Christopher, M. (2016). *Logistics & Supply Chain Management* (5th ed.). FT Press.

Cormier, G., & Gunn, E. (1992). A review of warehouse models. *European Journal of Operational Research, 58*, pp. 3-13.

Coyle, J., Bardi, E., & Langley, C. (1992). *Management of business logistics* (5th ed.). St. Paul: West Publishing.

Coyle, J., Langley, C., Novack, R., & Gibson, B. (2012). *Supply Chain Management: A Logistics Perspective* (9th ed.). South-Western College Pub.

CSCMP. (2013). Supply Chain Management Terms and Glossary.

de Koster , R., Le-Duc, T., & Roodbergen, K. (2007). Design and control of warehouse order picking: A literature review. *European Journal of Operational Research, 182*, pp. 481–501.

de Koster, R., & Van der Port, E. (1998). Routing orderpickers in a warehouse: a comparison between optimal and heuristic solutions. *IIE Transactions, 30*(5), pp. 469-480.

Drury, J. (1988). *Towards more eficient order picking.* Cranfield, U.K.: The Institute of Materials Management.

Dutta, S., Shah, H., Dasari, A., Singal, K., Harikeerthi, N., & Talakola, Y. (2017). Optimizing Inventory though ABC Classification and Demand Forecast. *American Society for Engineering Management*, pp. 1-8.

Eisenhardt, K. (1989). Building Theories from Case Study Research. *The Academy of Management Review, 14*(4), pp. 532-550.

Glock, C., & Grosse, E. (2012). Storage Policies and Order Picking Strategies in U-shaped Order-Picking Systems with a Movable Base. *International Journal of Production Research, 50*(16), pp. 4344-4357.

Goetschalckx, M., & Ratliff, H. (1988). Order Picking In An Aisle. *IIE Transactions, 20*(1), pp. 53-62.

Hall, R. (1993). Distances Approximations for Routing Manual Pickers in a Warehouse. *IIE Transactions, 25*(4), pp. 76-87.

Hausman, W., Schwarz, L., & Graves, S. (1976). Optimal Storage Assignment Automatic Warehousing Systems. *The Institute of Management Science, 22*(6), pp. 629-638.

Jarvis, J., & McDowell, E. (1991). Optimal Product Layout in an Order Picking Warehouse. *IIE Transactions, 23*(1), pp. 93-102.

Manzini, R., Gamberi, M., Persona, A., & Regattieri, A. (2007). Design of a class based storage picker to product order picking system. *International Journal of Advanced Manufacturing Technology, 32*, pp. 811–821.

Ohmae, K. (1982). *The mind of the strategist : the art of japanese business.* New York: McGraw-Hill.

Onwubolu, G., & Dube, B. (2006). Implementing an improved inventory control system in a small company: a case study. *Production Planning & Control, 17*, pp. 67-76.

Petersen, C., & Aase, G. (2004). A comparison of picking, storage, and routing policies in manualorder picking. *International Journal of Production Economics, 92*, pp. 11-19.

Rao, S., & Adil, G. (2013). Class-based storage with exact S-shaped traversal routeing in low-level picker-to-part systems. *International Journal of Production Research, 51*(16), pp. 4979-4996.

Ratliff, H., & Rosenthal, A. (1983). Order-Picking in a Rectangular Warehouse: A Solvable Case of the Traveling Salesman Problem. *Operations Research, 31*(3), pp. 507-521.

Roodbergen, K., & de Koster, R. (2001a). Routing order pickers in a warehouse with a middle aisle. *European Journal of Operational Research, 133*, pp. 32-43.

Roodbergen, K., & de Koster, R. (2001b). Routing methods for warehouses with multiple cross aisles. *International Journal of Production Research, 39*(9), pp. 1865-1883.

Roodbergen, K., Sharp, G., & Vis, I. (2008). Designing the layout structure of manual order picking areas in warehouses. *IIE Transactions, 40*(11), pp. 1032-1045.

Rushton, A., Croucher, P., & Baker, P. (2010). *The Handbook of Logistics & Distribution Management* (4th ed.). New Delhi: Kogan Page.

Stock, J., & Lambert, D. (2001). *Strategic logistics management* (4th ed.). New York: McGraw-Hill.

Tompkins, J. A., White, J., Bozer, Y., & Tanchoco, J. (2010). *Facilities Planning* (4th ed.). John Wiley & Sons.

Tompkins, J., & Smith, J. (1998). *The Warehouse Management Handbook* (2nd ed.). Tompkins Press.

Van den Berg, J., & Zijm, W. (1999). Models for warehouse management: ClassiÞcation and examples. *International Journal of Production Economics, 59*, pp. 519-528.

Vonderembse, M., & White, G. (1996). *Operations management : concepts, methods, and strategies* (3rd ed.). St. Paul: West Publishing.

Voss, C., Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. *International Journal of Operations & Production Management*, *22*(2), pp.195-219.

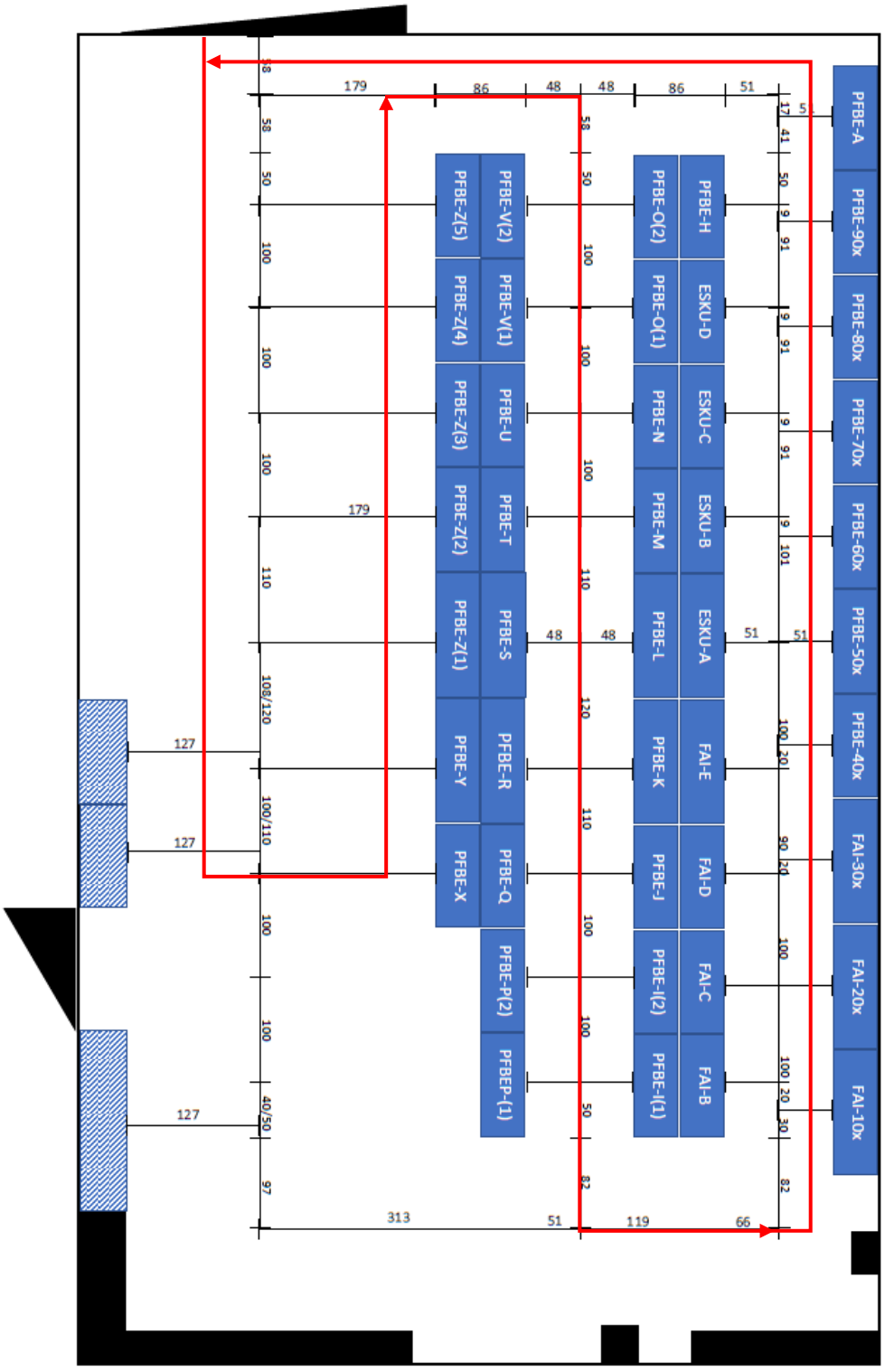
Yin, R. (2018). *Case Study Research and Applications: design and methods* (6th ed.). Los Angeles: SAGE.

8 Appendix

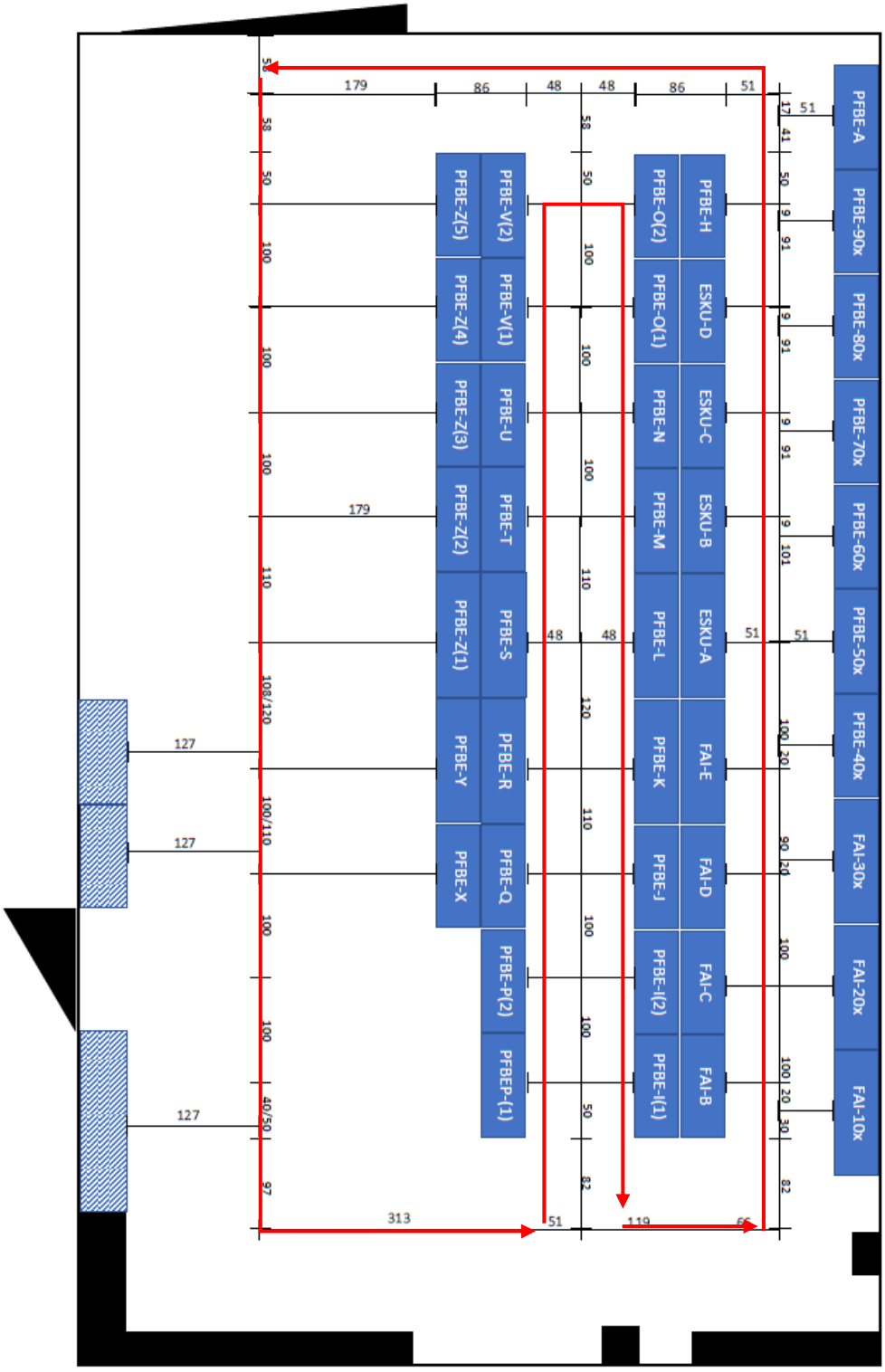
Appendix A – Unstructured Interviews Script

Stakeholder	Topic
Head of Logistics	Establishment of the project's specifications; Milestones' definition;
Picker	Warehouse process description – storage and picking activities;
Warehouse Manager	Warehouse processes' clarification; Improvements implemented over the past years;
Head of Logistics	Understanding Tactical decisions – storage and picking activities;

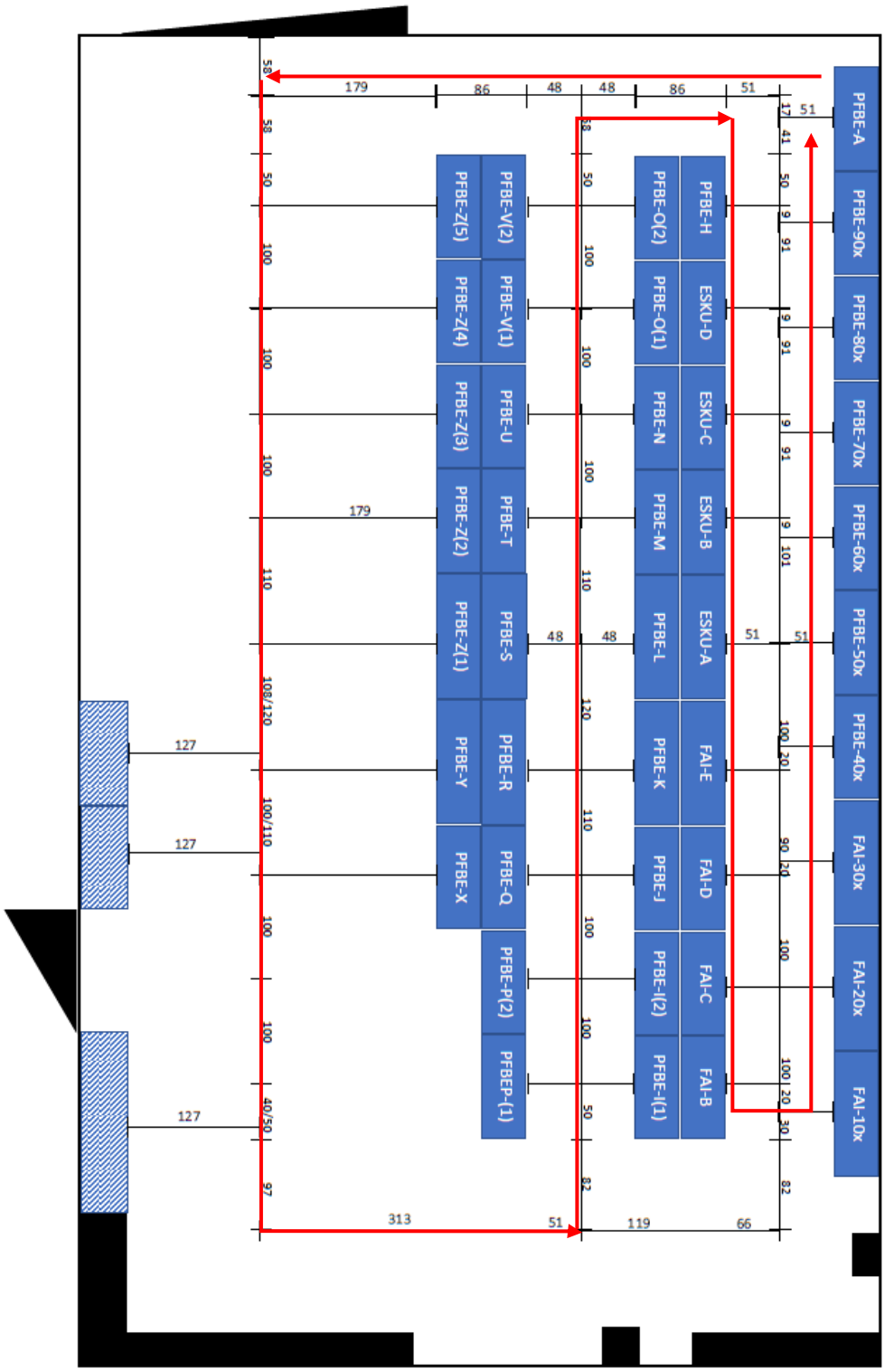
Appendix B – PR – 1 Representation



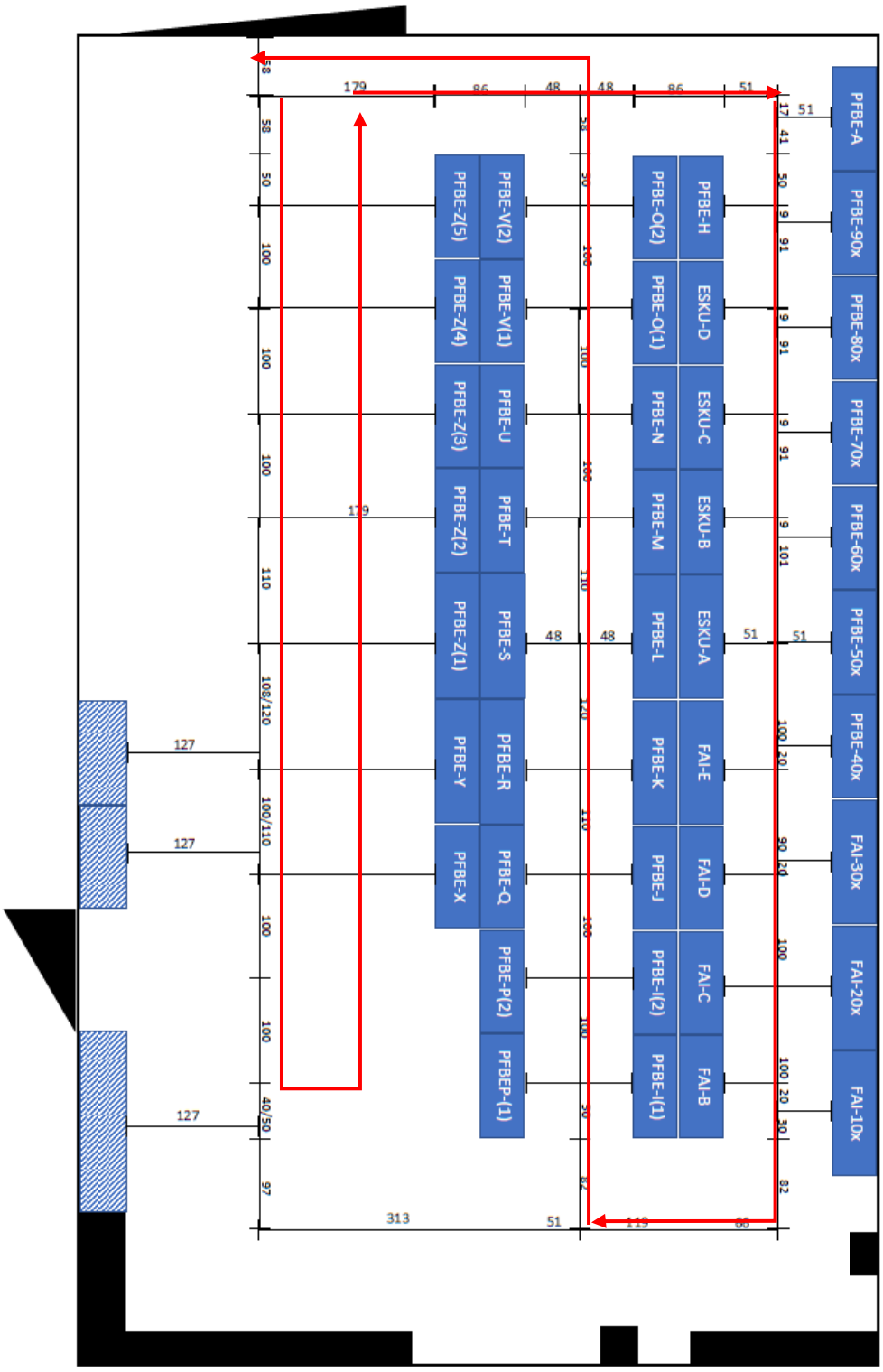
Appendix C – PR – 2 Representation



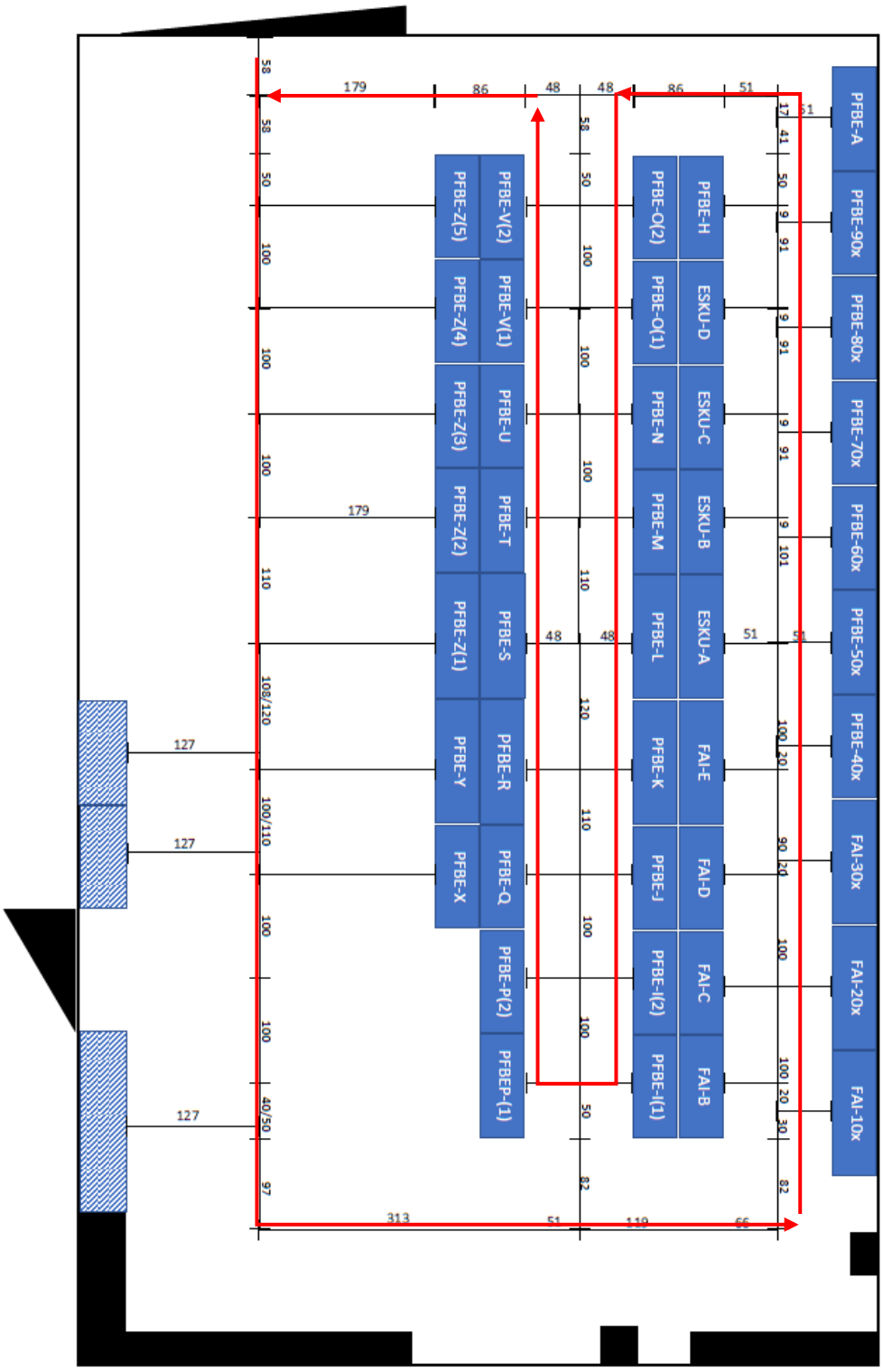
Appendix D – PR – 3 Representation



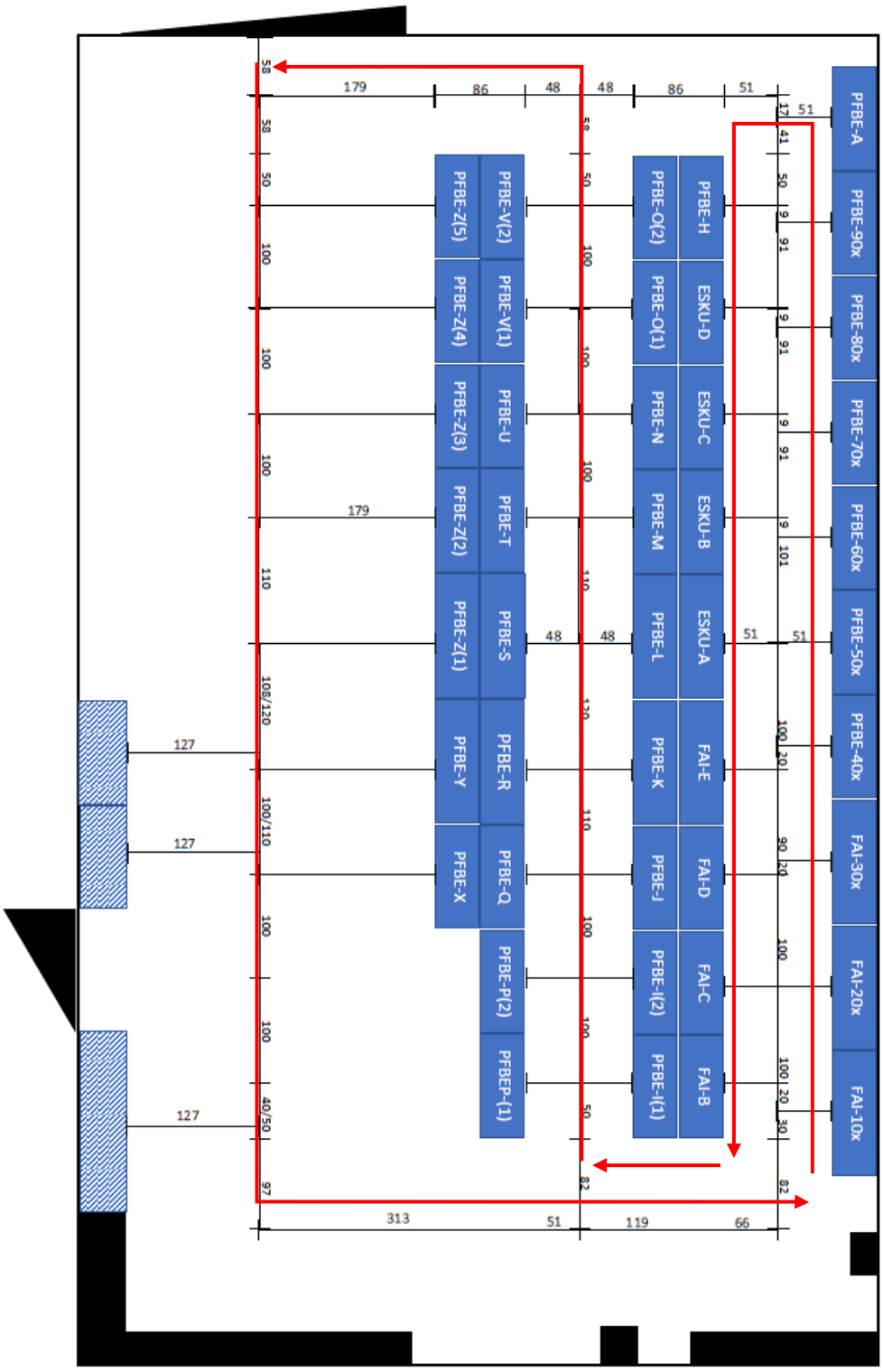
Appendix E – PR – 4 Representation



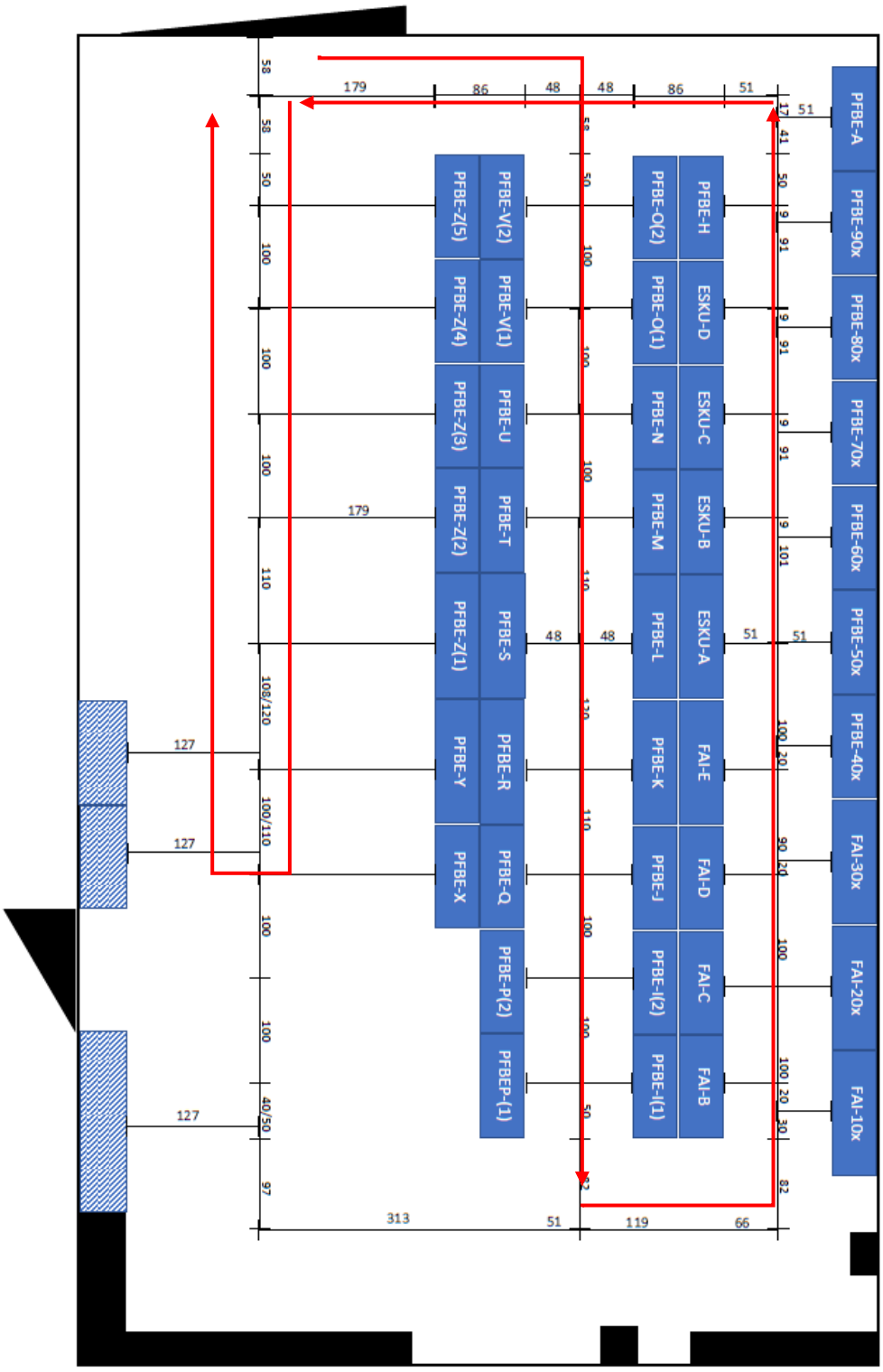
Appendix F – PR – 5 Representation



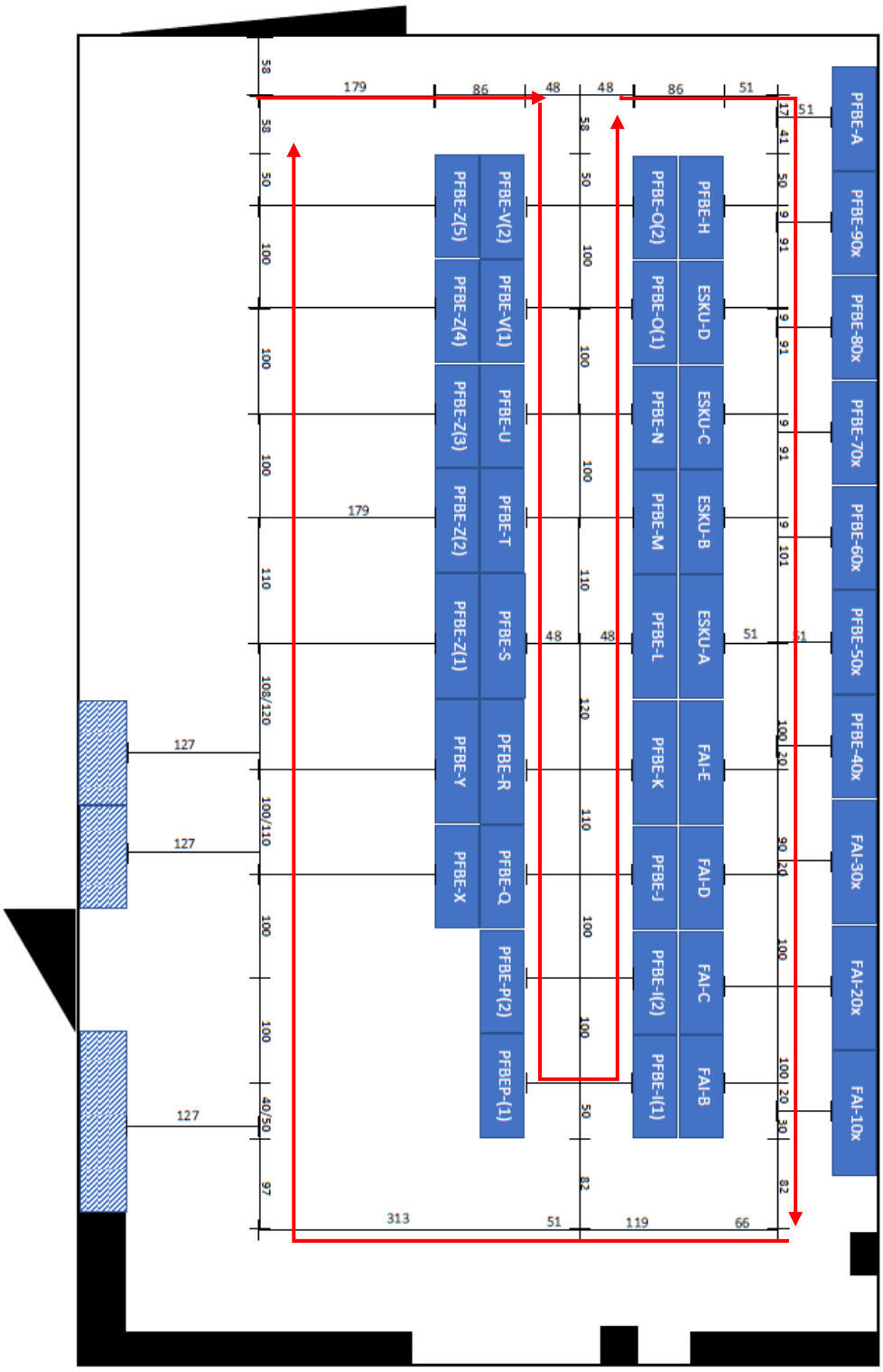
Appendix G – PR – 6 Representation



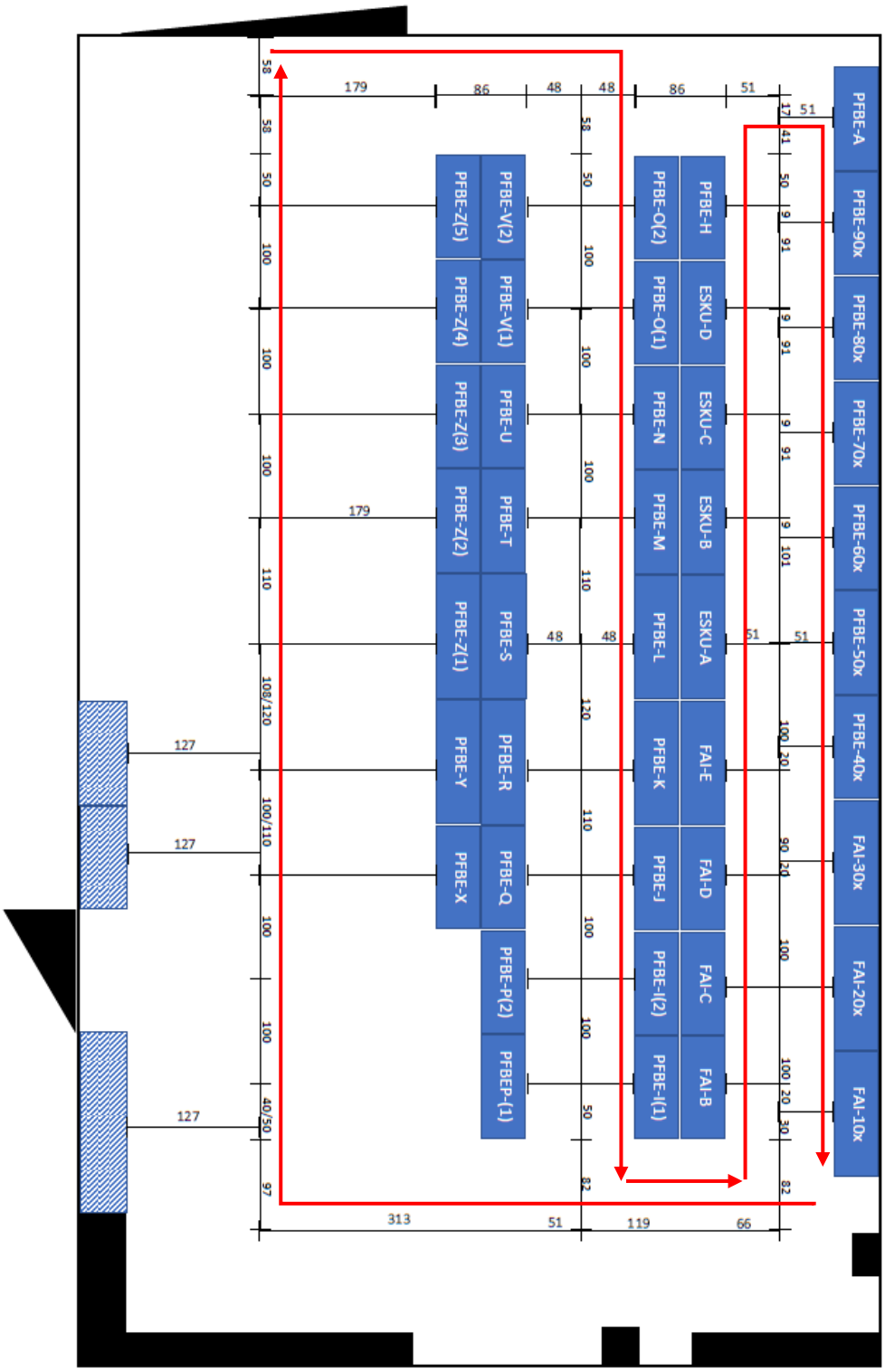
Appendix H – PR – 7 Representation



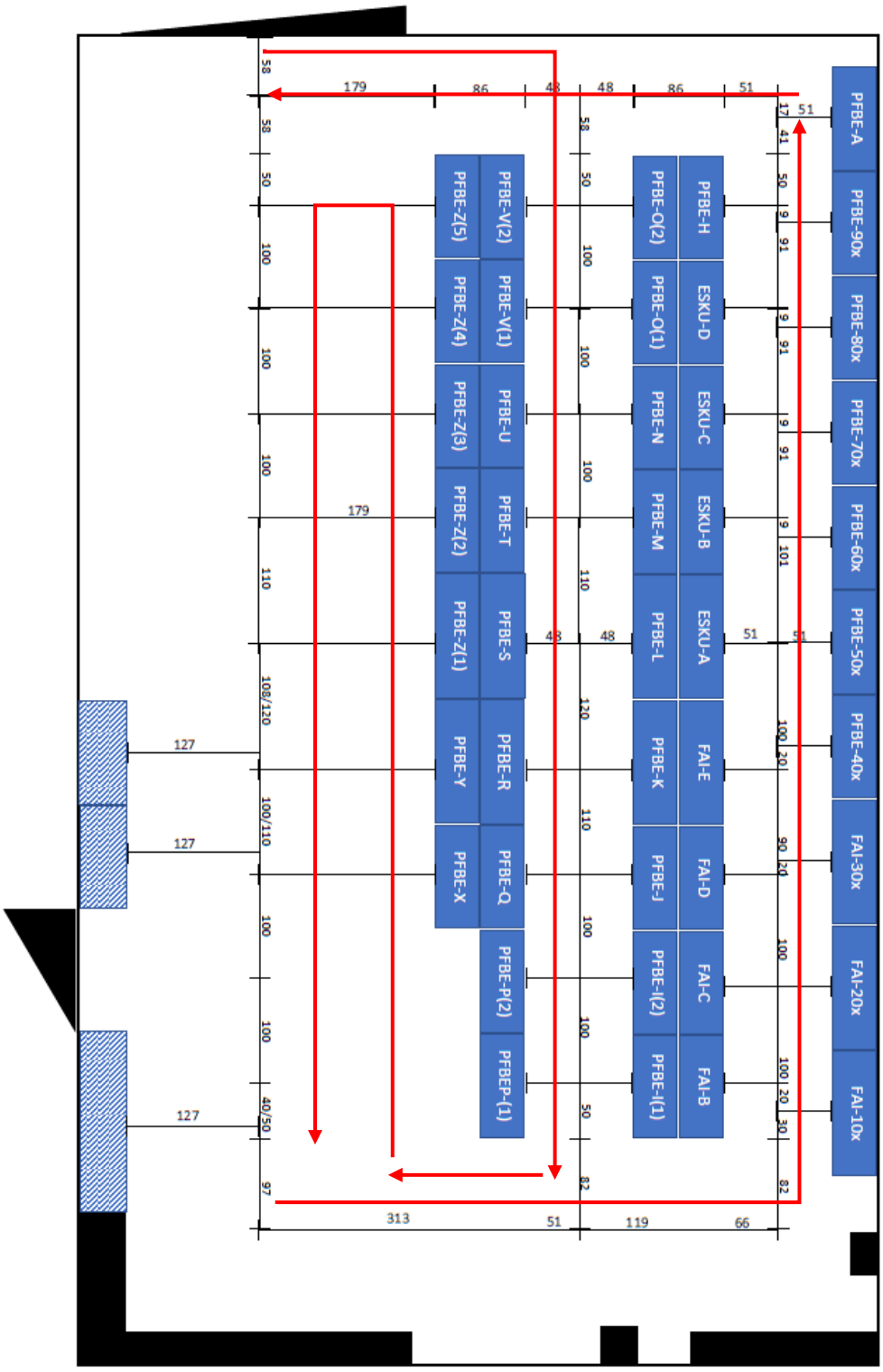
Appendix I – PR – 8 Representation



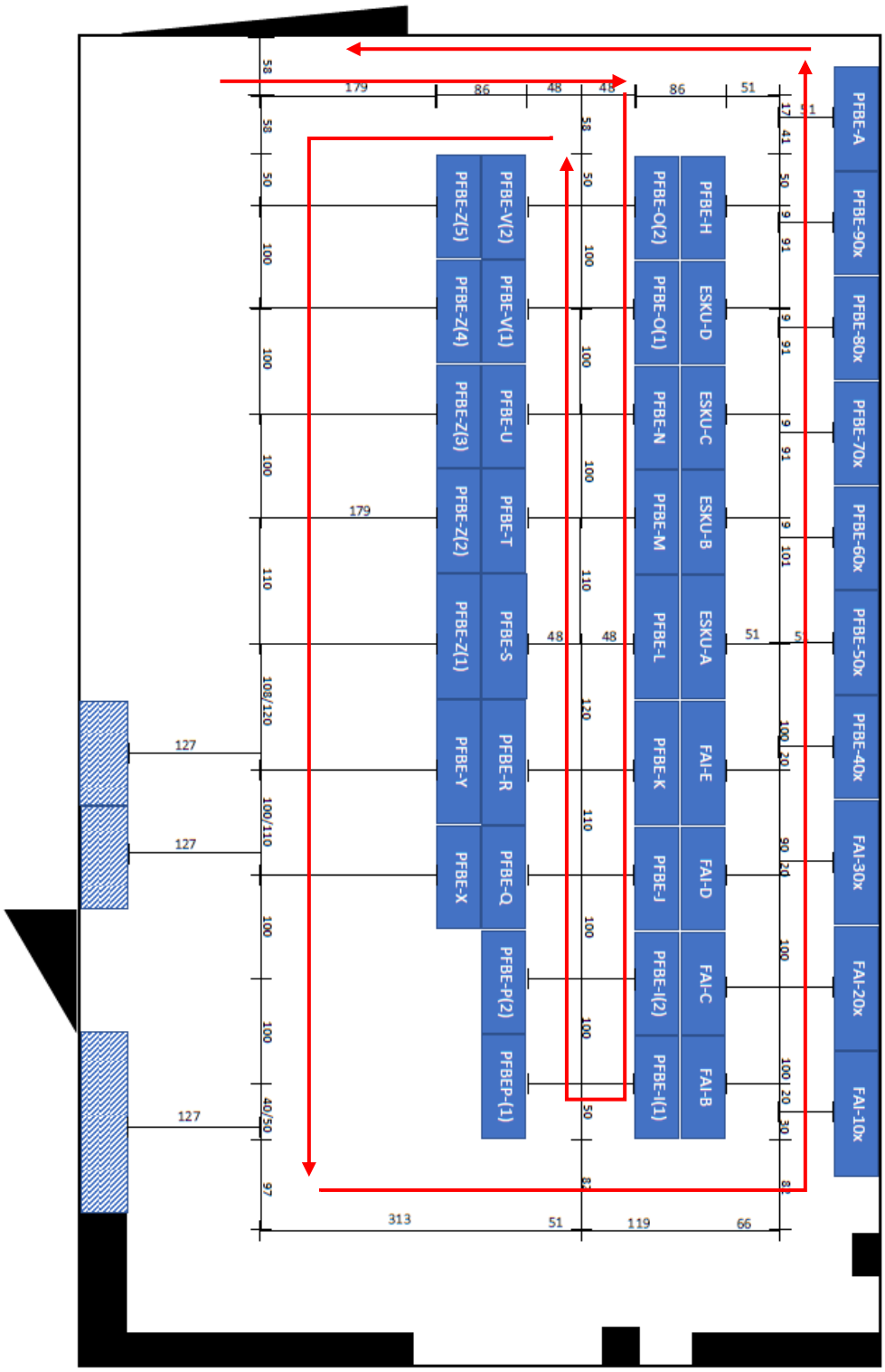
Appendix J – PR – 9 Representation



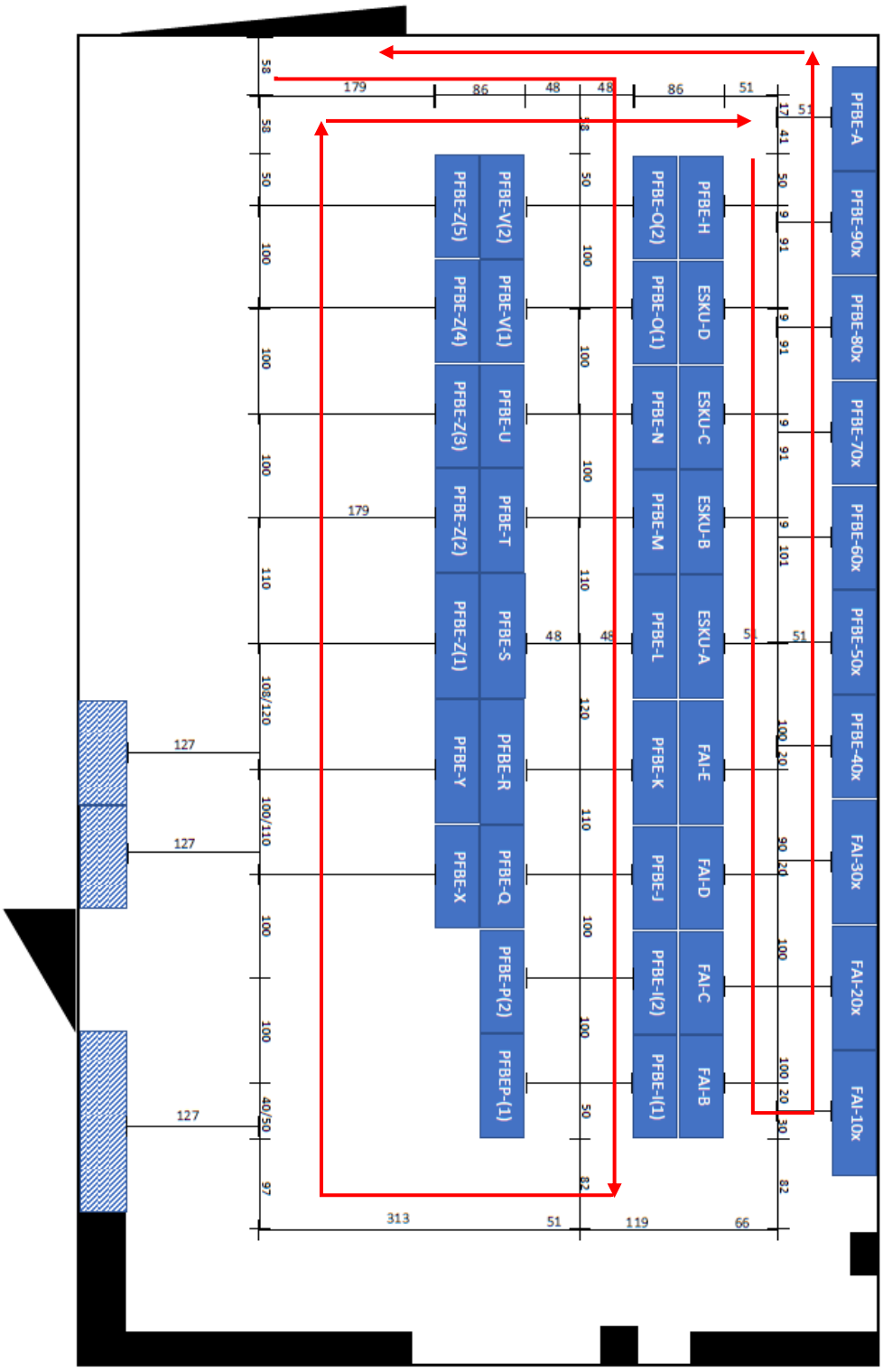
Appendix K – PR – 10 Representation



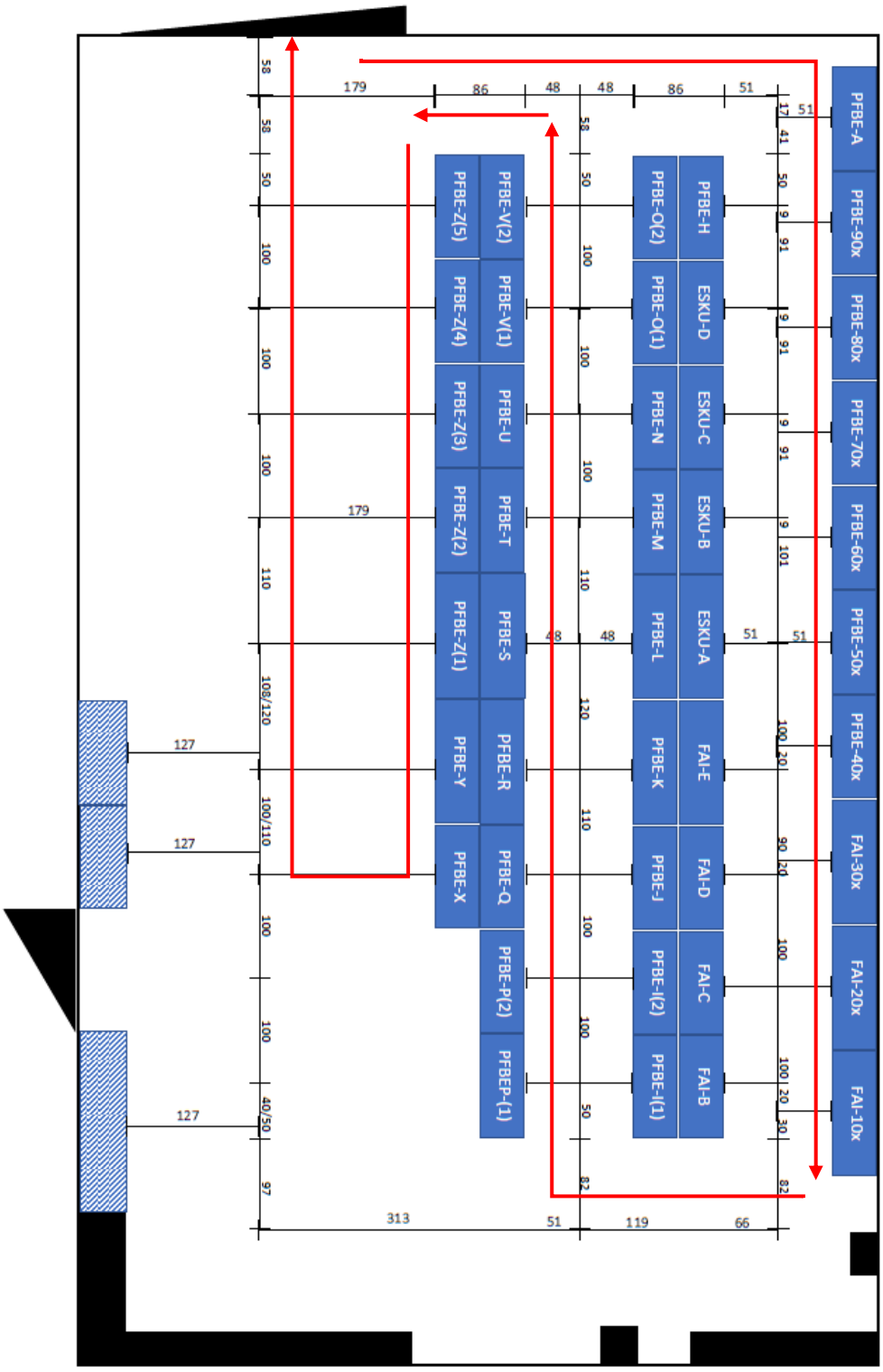
Appendix L – PR – 11 Representation



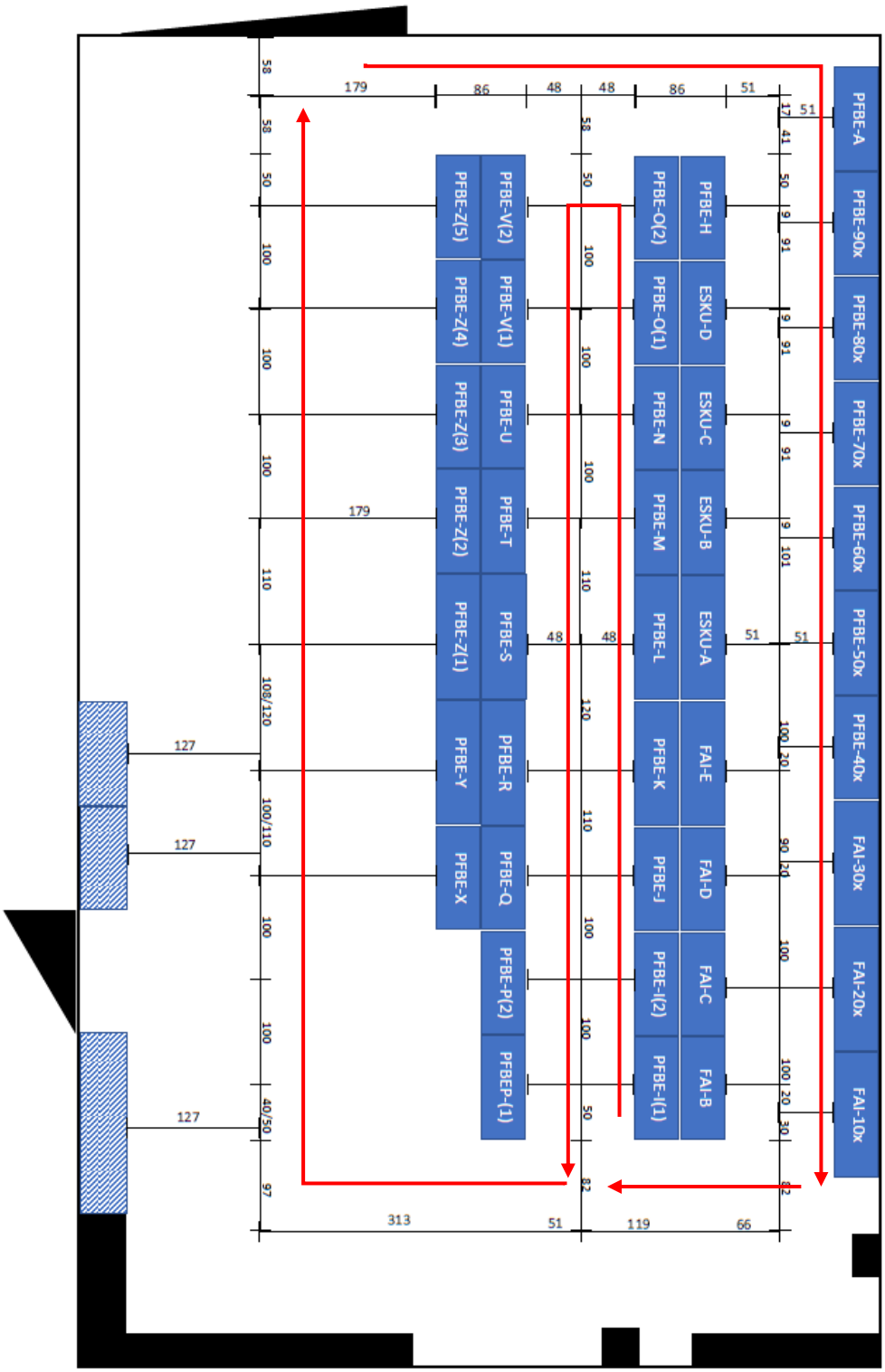
Appendix M – PR – 12 Representation



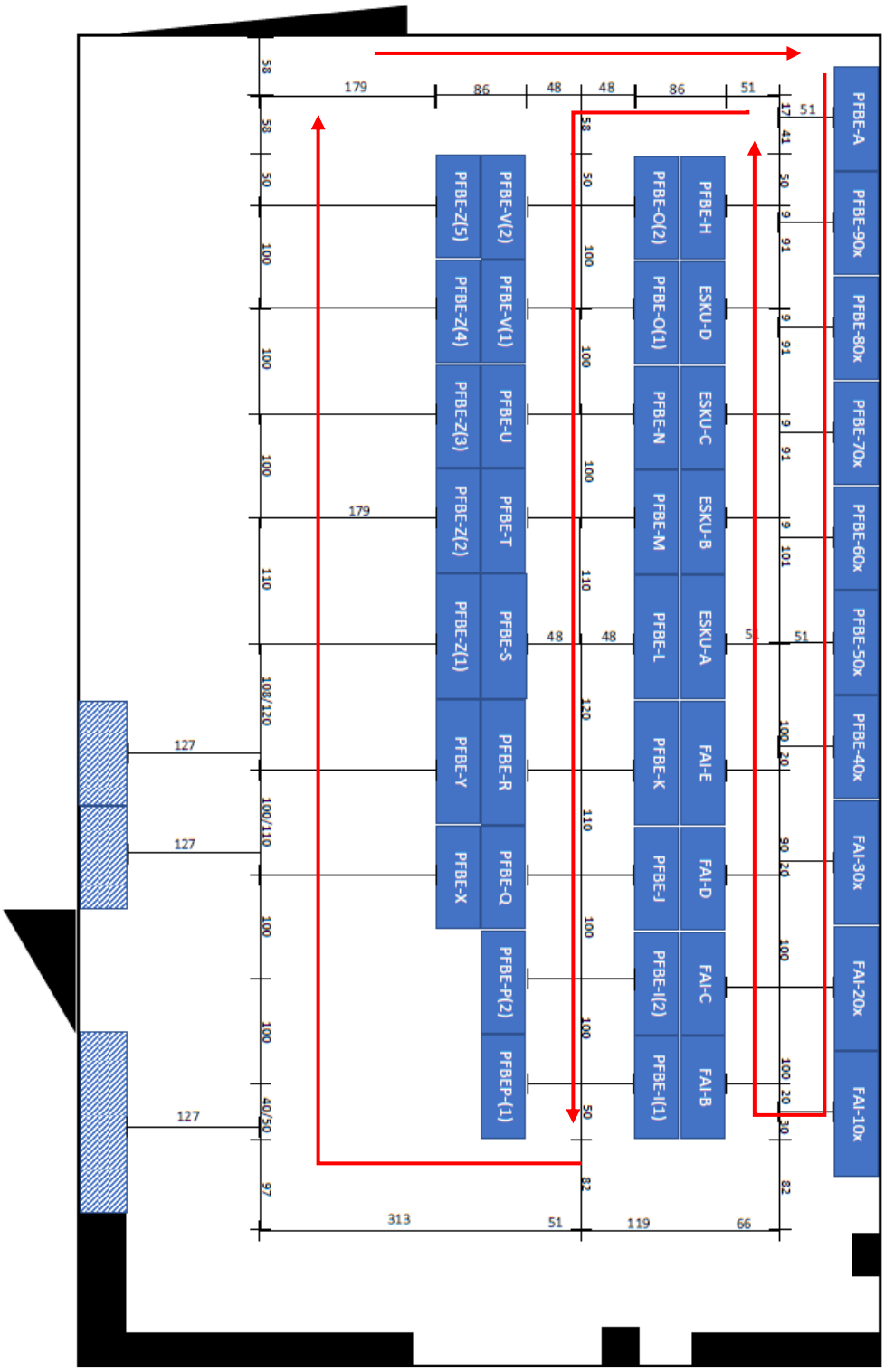
Appendix N – PR – 13 Representation



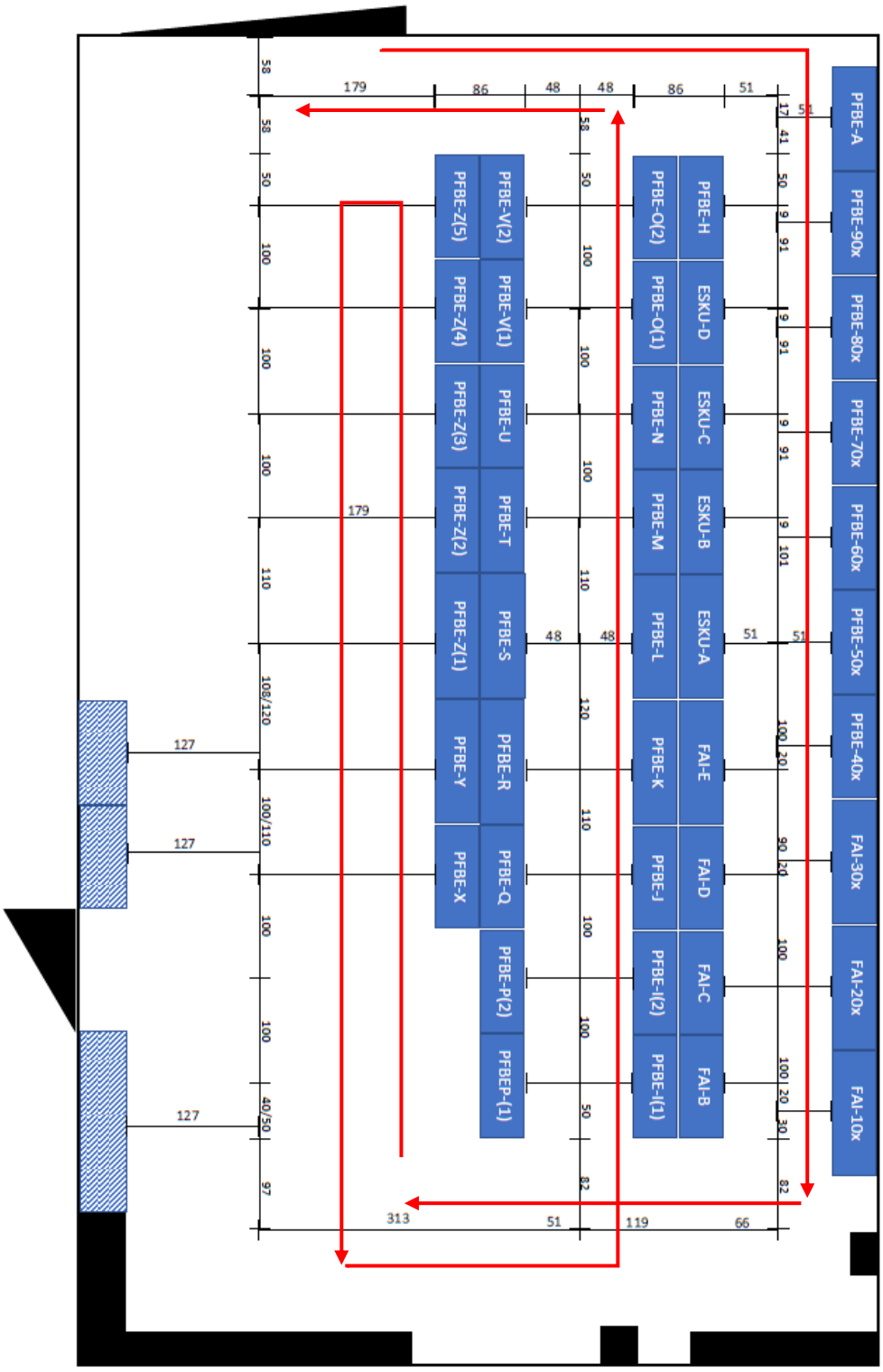
Appendix O – PR – 14 Representation



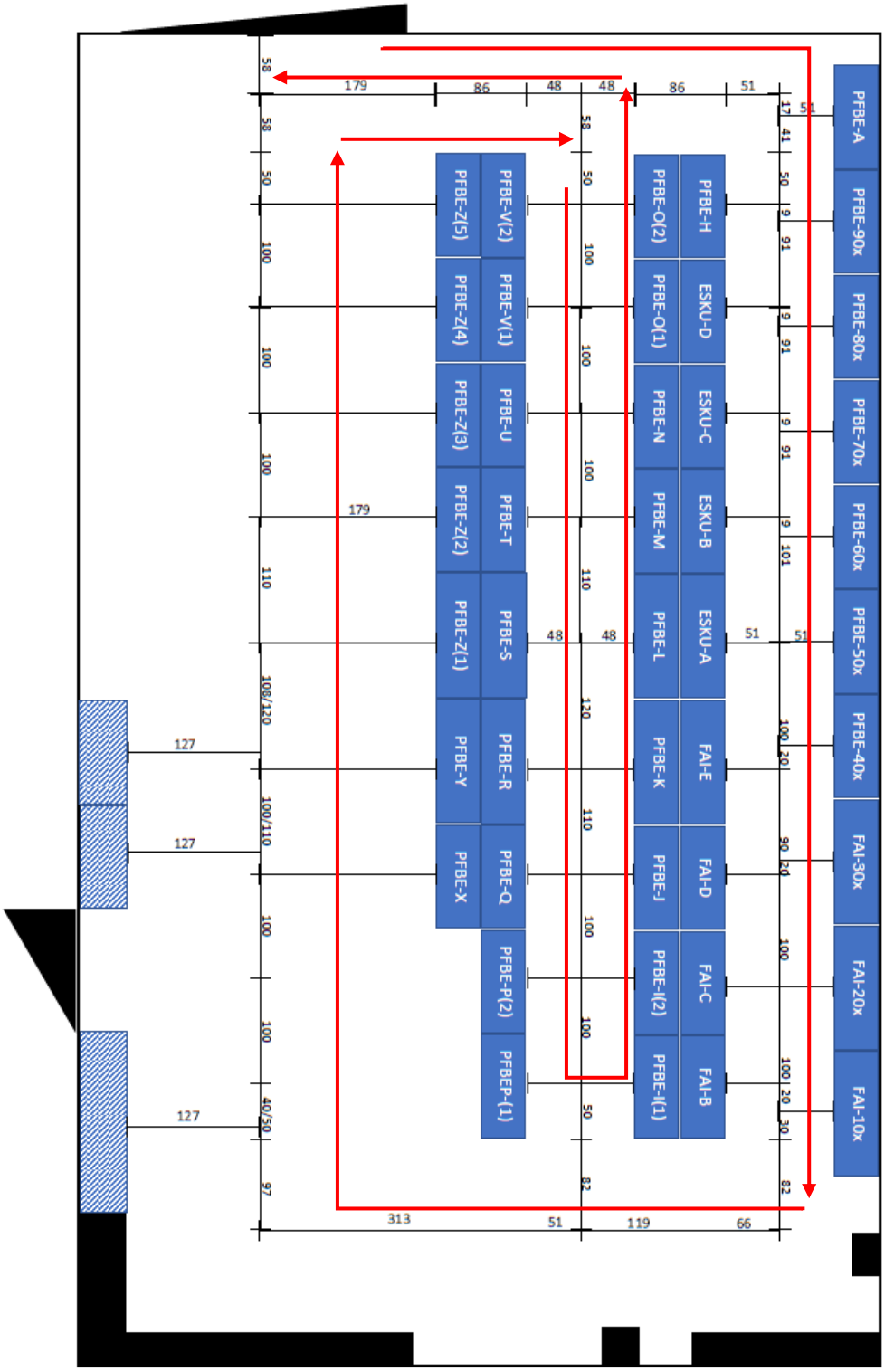
Appendix P – PR – 15 Representation



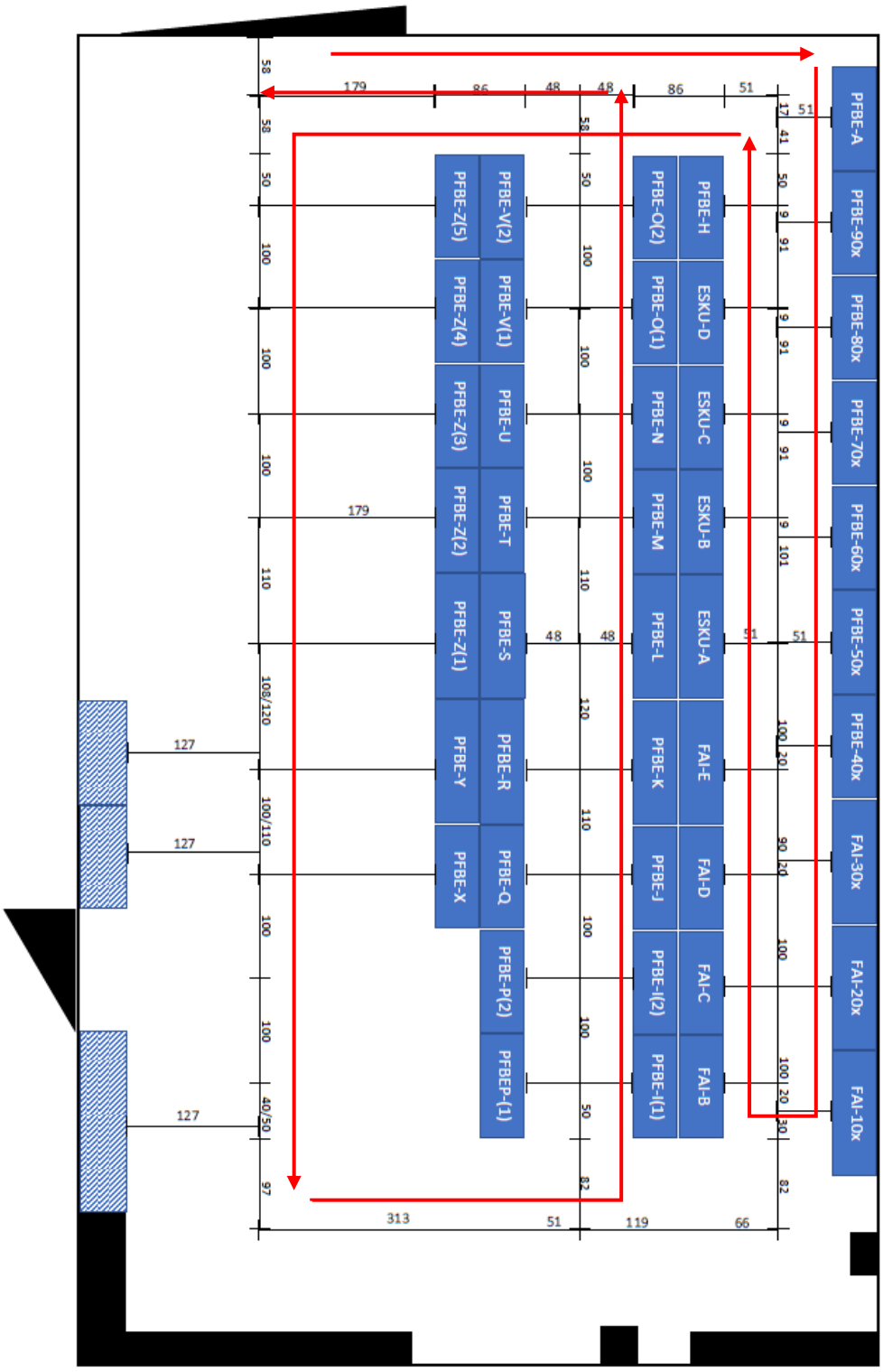
Appendix Q – PR – 16 Representation



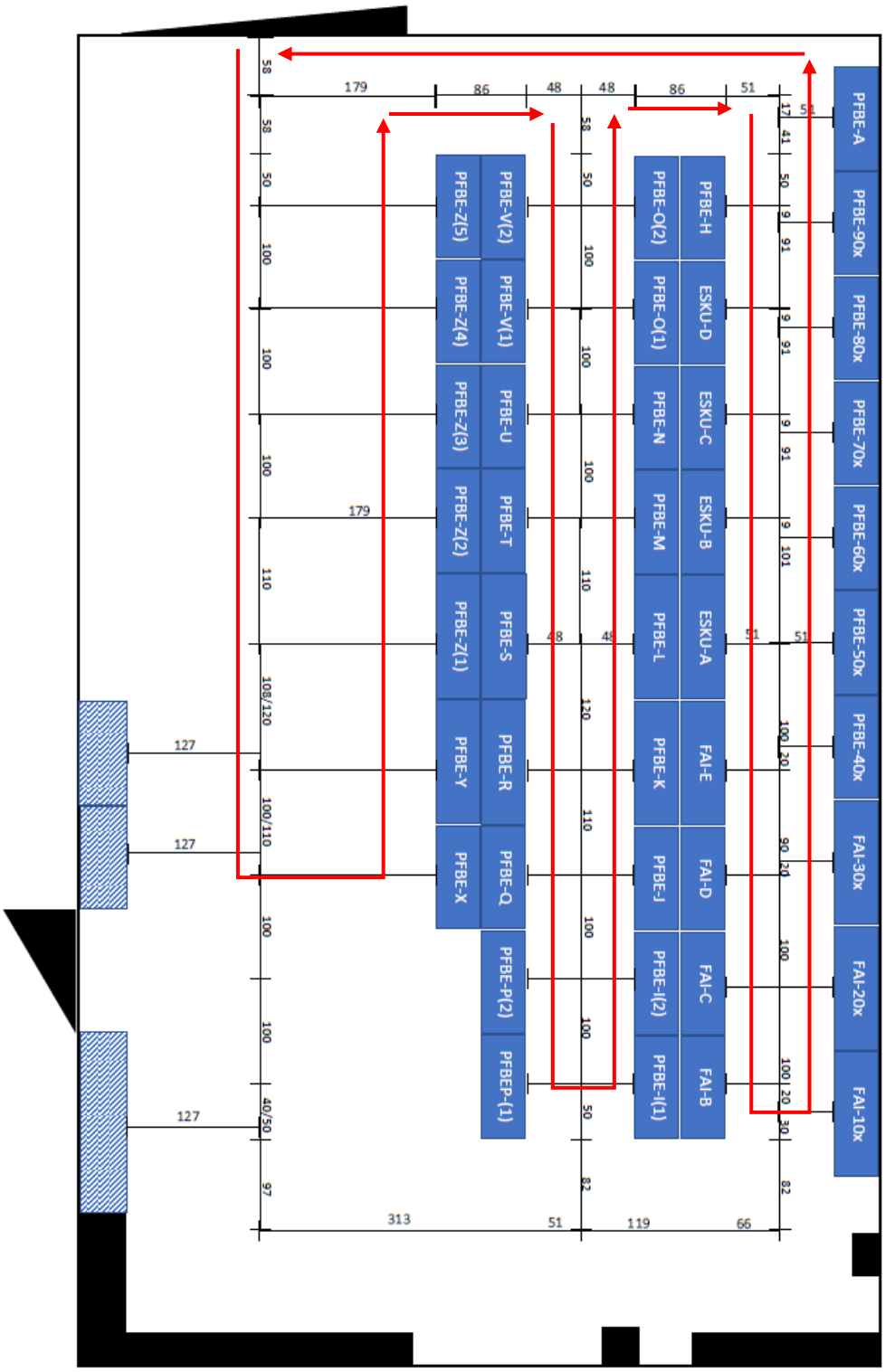
Appendix R – PR – 17 Representation



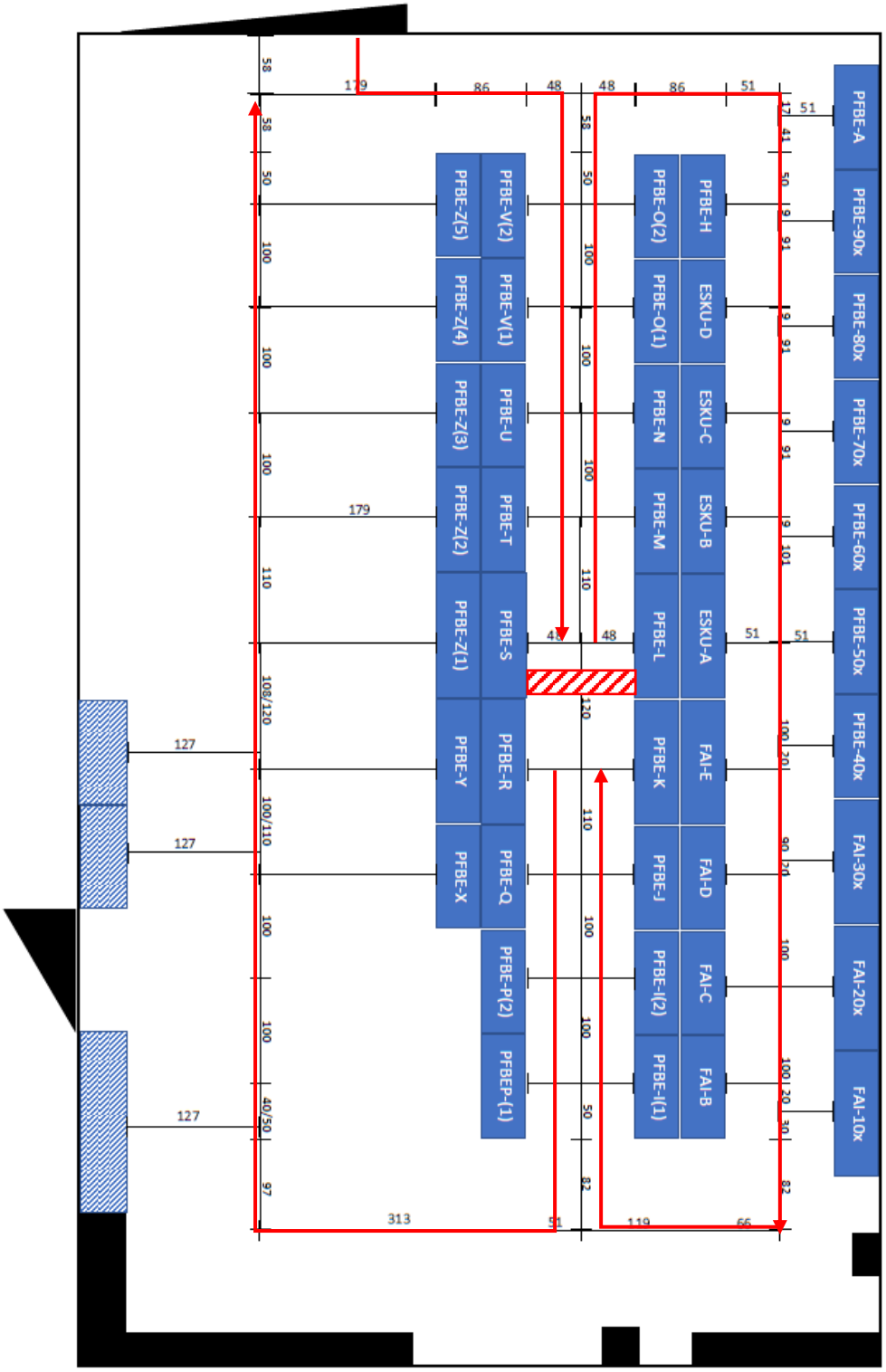
Appendix S – PR – 18 Representation



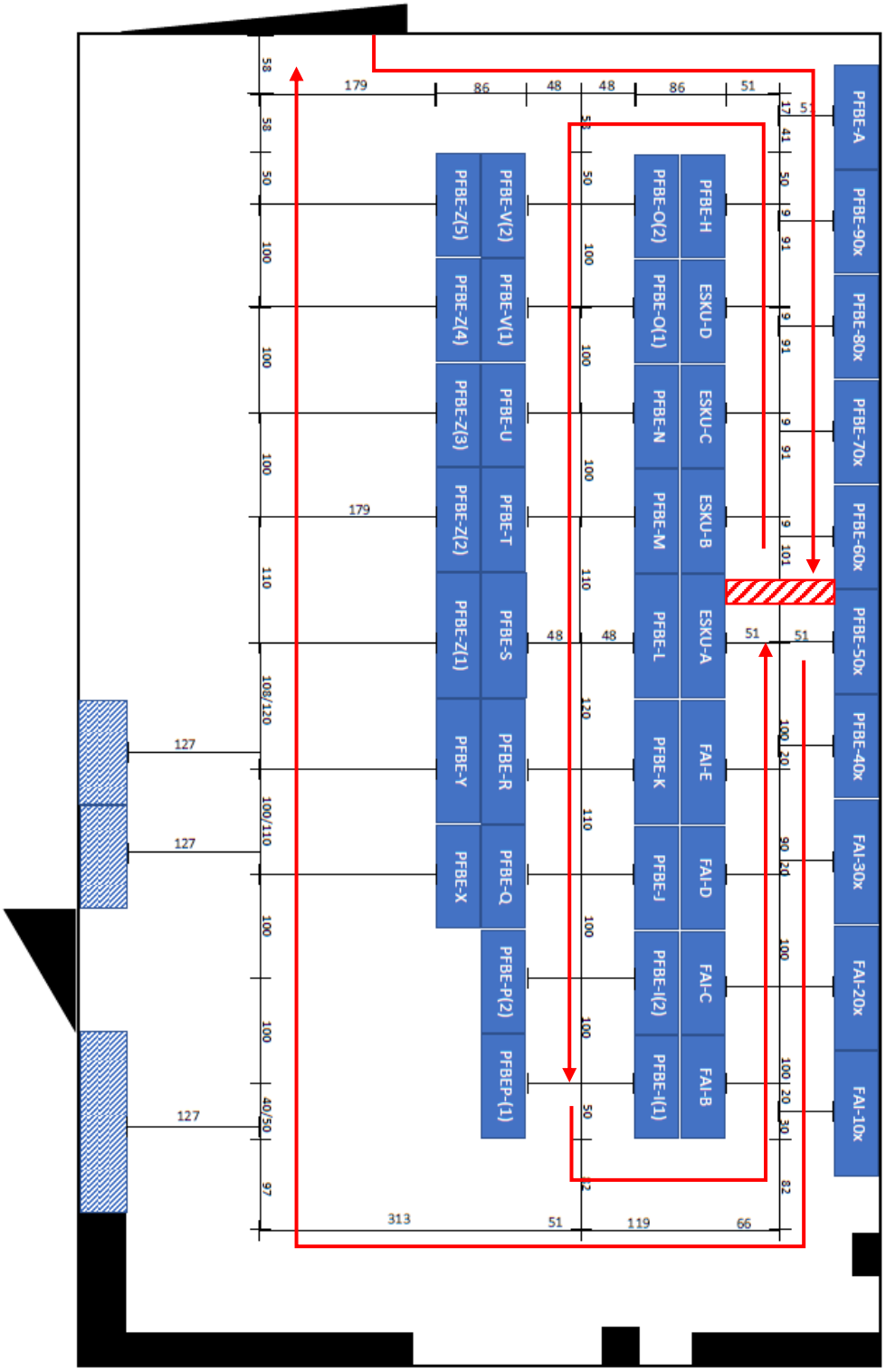
Appendix T – PR – 19 Representation



Appendix U – PR – 20 Representation



Appendix V – PR – 21 Representation



Appendix W - Distance Matrix

Shelf		Entry	PFBE																										ESKU				FAI												
			A	H	I1	I2	J	K	L	M	N	O1	O2	P1	P2	Q	R	S	T	U	V1	V2	X	Y	Z1	Z2	Z3	Z4	Z5	A	B	C	D	B	C	D	E	20x	30x	10x	40x	50x	60x	70x	80x	90x
Entry		-	624	715	1367	1267	1167	1057	937	827	727	627	527	1367	1267	1167	1057	937	827	727	627	527	985	875	755	645	545	445	345	1125	1015	915	815	1555	1455	1355	1245	1455	1335	1575	1225	1125	1024	924	824	724
PFBE	A	624	-	193	1249	1149	1049	939	819	709	609	509	409	1249	1149	1049	939	819	709	609	509	409	1493	1383	1263	1153	1053	953	853	620	510	410	310	1050	950	850	740	950	830	1070	720	620	519	419	319	219
	H	715	193	-	1340	1240	1140	1030	910	800	700	600	500	1340	1240	1140	1030	910	800	700	600	500	1584	1474	1354	1244	1144	1044	944	512	402	302	202	942	842	742	632	842	722	962	612	512	411	311	211	111
	I1	1367	1252	1340	-	196	296	406	526	636	736	836	936	96	196	296	406	526	636	736	836	936	1070	1180	1300	1410	1510	1610	1710	978	1088	1188	1288	548	648	748	858	648	768	528	878	978	1079	1179	1279	1379
	I2	1267	1152	1240	196	-	196	296	406	526	636	736	836	196	96	196	306	426	536	636	736	836	1170	1280	1400	1510	1610	1710	1810	1078	1188	1288	1388	648	748	848	958	748	868	628	978	1078	1179	1279	1349	1249
	J	1167	1052	1140	296	196	-	206	326	436	536	636	736	296	196	96	206	326	436	536	636	736	1270	1380	1500	1610	1596	1496	1396	1178	1288	1340	1240	748	848	948	1058	848	968	728	1078	1178	1279	1349	1249	1149
	K	1057	942	1030	406	296	206	-	216	326	426	526	626	406	306	206	96	216	326	426	526	626	1380	1490	1610	1586	1486	1386	1286	1288	1330	1230	1130	858	958	1058	1168	958	1078	838	1188	1288	1339	1239	1139	1039
	L	937	822	910	526	406	326	216	-	206	306	406	506	526	426	326	216	96	206	306	406	506	1500	1610	1576	1466	1366	1266	1166	1408	1518	1618	1718	978	1078	1178	1288	1078	1198	958	1308	1320	1219	1119	1019	919
	M	827	712	800	636	526	436	326	206	-	196	296	396	636	536	436	326	206	96	196	296	396	1610	1586	1466	1356	1256	1156	1056	1210	1100	1000	900	1088	1188	1288	1330	1188	1308	1068	1310	1210	1109	1009	909	809
	N	727	612	700	736	636	536	426	306	196	-	196	296	736	636	536	426	306	196	96	196	296	1596	1486	1366	1256	1156	1056	956	1110	1000	900	800	1188	1288	1340	1230	1288	1408	1168	1210	1110	1009	909	809	709
	O1	627	512	600	836	736	636	526	406	296	196	-	196	836	736	636	526	406	296	196	96	196	1496	1386	1266	1156	1056	956	856	1010	900	800	700	1288	1340	1240	1130	1340	1220	1268	1110	1010	909	809	709	609
	O2	527	412	500	936	836	736	626	506	396	296	196	-	936	836	736	626	506	396	296	196	96	1396	1286	1166	1056	956	856	756	910	800	700	600	1340	1240	1140	1030	1240	1120	1360	1010	910	809	709	609	509
	P1	1367	1252	1340	96	196	296	406	526	636	736	836	936	-	196	296	406	526	636	736	836	936	1070	1180	1300	1410	1510	1610	1596	978	1088	1188	1288	548	648	748	858	648	768	528	878	978	1079	1179	1279	1349
	P2	1267	1152	1240	196	96	196	306	426	536	636	736	836	196	-	196	306	426	536	636	736	836	1170	1280	1400	1510	1610	1596	1496	1078	1188	1288	1340	648	748	848	958	748	868	628	978	1078	1179	1279	1349	1249
	Q	1167	1052	1140	296	196	96	206	326	436	536	636	736	296	196	-	196	306	426	536	636	736	1270	1380	1500	1610	1596	1496	1396	1178	1288	1340	1240	748	848	948	1058	848	968	728	1078	1178	1279	1349	1249	1149
	R	1057	942	1030	406	306	206	96	216	326	426	526	626	406	306	196	-	216	326	426	526	626	1380	1490	1610	1586	1486	1386	1286	1278	1330	1230	1130	858	958	1058	1158	958	1078	838	1188	1288	1339	1239	1139	1039
	S	937	822	910	526	426	326	216	96	206	306	406	506	526	426	306	216	-	206	306	406	506	1500	1610	1576	1466	1366	1266	1166	1320	1210	1110	1010	978	1078	1178	1288	1078	1198	958	1308	1320	1219	1119	1019	919
	T	827	712	800	636	536	436	326	206	96	196	296	396	636	536	426	326	206	-	196	296	396	1696	1586	1466	1356	1256	1156	1056	1210	1100	1000	900	1088	1188	1288	1330	1188	1308	1068	1310	1210	1109	1009	909	809
	U	727	612	700	736	636	536	426	306	196	96	196	296	736	636	536	426	306	196	-	196	296	1596	1486	1366	1256	1156	1056	956	1110	1000	900	800	1188	1288	1340	1230	1288	1320	1168	1210	1110	1009	909	809	709
	V1	627	512	600	836	736	636	526	406	296	196	96	196	836	736	636	526	406	296	196	-	196	1496	1386	1266	1156	1056	956	856	1010	900	800	700	1288	1340	1240	1130	1340	1220	1268	1110	1010	909	809	709	609
	V2	527	412	500	936	836	736	626	506	396	296	196	96	936	836	736	626	506	396	296	196	-	1396	1286	1166	1056	956	856	756	910	800	700	600	1340	1240	1140	1030	1240	1120	1360	1010	910	809	709	609	509
	X	985	1493	1584	1070	1170	1270	1380	1500	1610	1596	1496	1396	1070	1170	1270	1380	1500	1696	1596	1496	1396	-	468	588	698	798	898	998	1688	1798	1784	1684	1258	1358	1458	1568	1358	1478	1238	1588	1688	1789	1793	1693	1593
	Y	875	1383	1474	1180	1280	1380	1490	1610	1586	1486	1386	1286	1180	1280	1380	1490	1610	1586	1486	1386	1286	468	-	478	588	688	788	888	1798	1774	1674	1574	1368	1468	1568	1678	1468	1588	1348	1698	1798	1783	1683	1583	1483
	Z1	755	1263	1354	1300	1400	1500	1610	1576	1466	1366	1266	1166	1300	1400	1500	1610	1576	1466	1366	1266	1166	588	478	-	468	568	668	768	1754	1654	1554	1454	1488	1588	1688	1798	1588	1708	1468	1818	1764	1663	1563	1463	1363
	Z2	645	1153	1244	1410	1510	1610	1586	1466	1356	1256	1156	1056	1410	1510	1610	1586	1466	1356	1256	1156	1056	698	588	468	-	458	558	658	1654	1544	1444	1344	1598	1698	1798	1774	1698	1818	1578	1754	1654	1553	1453	1353	1253
	Z3	545	1053	1144	1510	1610	1596	1486	1366	1256	1156	1056	956	1510	1610	1596	1486	1366	1256	1156	1056	956	798	688	568	458	-	458	558	1554	1444	1344	1244	1698	1798	1784	1674	1884	1764	1878	1654	1554	1453	1353	1253	1153
	Z4	445	953	1044	1610	1710	1496	1386	1266	1156	1056	956	856	1610	1596	1496	1386	1266	1156	1056	956	856	898	788	668	558	458	-	458	1454	1344	1244	1144	1798	1784	1684	1574	1784	1664	1778	1554	1454	1353	1253	1153	1053
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	B	1015	510	402	1088	1188	1288	1330	1518	1100	1000	900	800	1088	1188	1288	1330	1210	1100	1000	900	800	1798	1774	1654	1544	1444	1344	1244	212	-	202	302	642	542	442	332	542	422	662	312	212	111	193	293	393
	C	915	410	302	1188	1288	1340	1230	1618	1000	900	800	700	1188	1288	1340	1230	1110	1000	900	800	700	1784	1674	1554	1444	1344	1244	1144	312	202	-	202	742	642	542	432	642	522	762	412	312	211	111	193	293
	D	815	310	202	1288	1388	1240	1130	1718	900	800	700	600	1288	1340	1240	1130	1010	900	800	700	600	1684	1574	1454	1344	1244	1144	1044	412	302	202	-	842	742	642	532	742	622	862	512	412	312	211	111	193
FAI	B	1555	1050	942	548	648	748	858	978	1088	1188	1288	1340	548	648	748	858	978	1088	1188	1288	1340	1258	1368	1488	1598	1698	1798	1784	532	642	742	842	-	202	302	412	202	322	122	432	532	633	733	833	933
	C	1455	950	842	648	748	848	958	1078	1188	1288	1340	1240	648	748	848	958	1078	1188	1288	1340	1240	1358	1468	1588	1698	1798	1784	1684	432	542	642	742	202	-	202	312	102	222	222	332	432	533	633	733	833
	D	1355	850	742	748	848	948	1058	1178	1288	1340	1240	1140	748	848	948	1058	1178	1288	1340	1240	1140	1458	1568	1688	1798	1784	1684	1584	332	442	542	642	302	202	-	212	202	122	322	232	332	433	533	633	733
	E	1245	740	632	858	958	1058	1168	1288	1330	1230	1130	1030	858	958	1058	1158	1288	1330	1230	1130	1030	1568	1678	1798	1774	1674	1574	1474	222	332	432	532	412	312	212	-	312	192	432	122	222	323	423	523	623
	20x	1455	950	842	648	748	848	958	1078	1188	1288	1340	1240	648	748	848	958	1078	1188	1288	1340	1240	1358	1468	1588	1698	1884	1784	1684	432	542	642	742	202	102	202	312	-	222	222	332	432	533	633	733	833
	30x	1335	830	722	768	868	968	1078	1198	1308	1408	1220	1120	768	868	968	1078	1198	1308	1320	1220	1120	1478	1588	1708	1818	1764	1664	1564	312	422	522	622	322	222	122	192	222	-	342	212	312	413	513	613	713
	10x	1575	1070	962	528	628	728	838	958	1068	1168	1268	1360	528	628	728	838	958	1068	1168	1268	1360	1238	1348	1468	1578	1878	1778	1804	552	662	762	862	122	222	322	432	222	342	-	452	552	653	753	853	953
	40x	1225	720	612	878	978	1078	1188	1308	1310	1210	1110	1010	878	978	1078	1188	1308	1310	1210	1110	1010	1588	1698	1818	1754	1654	1554	1454	202	312	412	512	432	332	232	122	332	212	452	-	202	303	403	503	603
	50x	1125	620	512	978	1078	1178	1288	1320	1210	1110	1010	910	978	1078	1178	1288	1320	1210	1110	1010	910	1688	1798	1764	1654	1554	1454	1354	102	212	312	412	532	432	332	222	432	312	552	202	-	203	303	403	503
	60x	1024	519	411	1079	1179	1279	1339	1219	1109	1009	909	809	1079	1179	1279	1339	1219	1109	1009	909	809	1789	1783	1663	1553	1453	1353	1253	203	111	211	312	633	533	433	323	533	413	653	303	203	-	202	302	402
	70x	924	419	311	1179	1279	1349	1239	1119	1009	909	809	709	1179	1279	1349	1239	1119	1009	909	809	709	1793	1683	1563	1453	1353	1253	1153	303	193	111	211	733	633	533	423	633	513	753	403	303	202	-	202	302
	80x	824	319	211	1279	1349	1249	1139	1019	909	809	709	609	1279	1349	1249	1139	1019	909	809	709	609	1693	1583	1463	1353	1253	1153	1053	403	293	193	111	833	733	633	523	733	613	853	503	403	302	202	-	202
	90x	724	219	111	1379	1249	1149	1039	919	809	709	609	509	1349	1249	1149	1039	919	809	709	609	509	1593	1483	1363	1253	1153	1053	953	503	393	293	193	933	833	733	623	833	713	953	603	503	402	302	202	-

Appendix X – Available Volume per Shelf, in cm3

Shelf	Levels							Available Space
	1	2	3	4	5	6	7	
PFBE-A	120 400	120 400	106 560	88 200	106 560	120 400	73 100	735 620
PFBE-H	105 840	105 840	120 400	120 400	106 560	120 400	120 400	799 840
PFBE-I1	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-I2	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-J	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-K	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-L	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-M	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-N	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-O1	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-O2	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-P1	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-P2	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-Q	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-R	144 480	144 480	144 480	144 480	106 560	87 720	87 720	859 920
PFBE-S	144 480	144 480	144 480	144 480	106 560	87 720	87 720	859 920
PFBE-T	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-U	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-V1	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-V2	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-X	144 480	144 480	144 480	144 480	144 480	87 720	87 720	897 840
PFBE-Y	120 400	120 400	120 400	120 400	120 400	73 100	73 100	748 200
PFBE-Z1	144 480	144 480	144 480	144 480	133 200	87 720	87 720	886 560
PFBE-Z2	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-Z3	120 400	120 400	120 400	120 400	106 560	73 100	73 100	734 360
PFBE-Z4	120 400	120 400	120 400	106 560	106 560	73 100	73 100	720 520
PFBE-Z5	120 400	120 400	88 200	106 560	106 560	73 100	73 100	688 320
ESKU-A	132 480	132 480	133 200	133 200	133 200	120 400	120 400	905 360
ESKU-B	105 840	105 840	106 560	106 560	106 560	120 400	120 400	772 160
ESKU-C	105 840	105 840	106 560	106 560	106 560	120 400	120 400	772 160
ESKU-D	105 840	105 840	106 560	106 560	106 560	120 400	120 400	772 160
FAI-B	120 400	120 400	105 840	106 560	106 560	120 400	120 400	800 560
FAI-C	120 400	120 400	105 840	106 560	106 560	120 400	120 400	800 560
FAI-D	120 400	120 400	120 400	120 400	120 400	120 400	120 400	842 800
FAI-E	144 480	144 480	144 480	144 480	144 480	144 480	144 480	1 011 360
FAI-20x	144 480	144 480	144 480	144 480	144 480	144 480	87 720	954 600
FAI-30x	144 480	144 480	144 480	144 480	144 480	144 480	87 720	954 600
FAI-10X	144 480	132 480	133 200	133 200	133 200	144 480	87 720	908 760
PFBE-40x	105 840	105 840	105 840	106 560	106 560	120 400	73 100	724 140
PFBE-50x	105 840	105 840	106 560	106 560	106 560	120 400	73 100	724 860

PFBE-60x	105 840	105 840	120 400	88 200	106 560	120 400	73 100	720 340
PFBE-70x	105 840	105 840	120 400	88 200	106 560	120 400	73 100	720 340
PFBE-80x	120 400	120 400	120 400	88 200	106 560	120 400	73 100	749 460
PFBE-90x	120 400	120 400	106 560	88 200	106 560	120 400	73 100	735 620

Appendix Y – ABC Analysis: PFBE Family

SKU	%	Picking Frequency			Class	Sub-Family
		Picks	%	Cumulative		
Product 672	0,21%	9	1,08%	1,08%	A	Big
Product 270	0,42%	8	0,96%	2,04%	A	Big
Product 1515	0,64%	7	0,84%	2,88%	A	Big
Product 192	0,85%	7	0,84%	3,72%	A	Big
Product 1768	1,06%	6	0,72%	4,44%	A	Big
Product 1710	1,27%	6	0,72%	5,16%	A	Big
Product 818	1,49%	6	0,72%	5,88%	A	Big
Product 813	1,70%	6	0,72%	6,59%	A	Big
Product 207	1,91%	6	0,72%	7,31%	A	Big
Product 202	2,12%	6	0,72%	8,03%	A	Big
Product 697	2,34%	5	0,60%	8,63%	A	Big
Product 708	2,55%	5	0,60%	9,23%	A	Big
Product 591	2,76%	5	0,60%	9,83%	A	Big
Product 741	2,97%	5	0,60%	10,43%	A	Big
Product 417	3,18%	5	0,60%	11,03%	A	Big
Product 134	3,40%	5	0,60%	11,63%	A	Big
Product 1474	3,61%	5	0,60%	12,23%	A	Medium
Product 673	3,82%	4	0,48%	12,71%	A	Big
Product 676	4,03%	4	0,48%	13,19%	A	Big
Product 699	4,25%	4	0,48%	13,67%	A	Big
Product 707	4,46%	4	0,48%	14,15%	A	Big
Product 731	4,67%	4	0,48%	14,63%	A	Big
Product 732	4,88%	4	0,48%	15,11%	A	Big
Product 567	5,10%	4	0,48%	15,59%	A	Big
Product 775	5,31%	4	0,48%	16,07%	A	Big
Product 777	5,52%	4	0,48%	16,55%	A	Big
Product 1763	5,73%	4	0,48%	17,03%	A	Big
Product 799	5,94%	4	0,48%	17,51%	A	Big
Product 806	6,16%	4	0,48%	17,99%	A	Big
Product 419	6,37%	4	0,48%	18,47%	A	Big
Product 388	6,58%	4	0,48%	18,94%	A	Big
Product 858	6,79%	4	0,48%	19,42%	A	Big
Product 2376	7,01%	4	0,48%	19,90%	A	Small
Product 788	7,22%	3	0,36%	20,26%	A	Big
Product 698	7,43%	3	0,36%	20,62%	A	Big
Product 669	7,64%	3	0,36%	20,98%	A	Big
Product 679	7,86%	3	0,36%	21,34%	A	Big
Product 655	8,07%	3	0,36%	21,70%	A	Big
Product 653	8,28%	3	0,36%	22,06%	A	Big

Product 648	8,49%	3	0,36%	22,42%	A	Big
Product 640	8,70%	3	0,36%	22,78%	A	Big
Product 2025	8,92%	3	0,36%	23,14%	A	Big
Product 721	9,13%	3	0,36%	23,50%	A	Big
Product 723	9,34%	3	0,36%	23,86%	A	Big
Product 727	9,55%	3	0,36%	24,22%	A	Big
Product 736	9,77%	3	0,36%	24,58%	A	Big
Product 557	9,98%	3	0,36%	24,94%	A	Big
Product 737	10,19%	3	0,36%	25,30%	A	Big
Product 1891	10,40%	3	0,36%	25,66%	A	Big
Product 746	10,62%	3	0,36%	26,02%	A	Big
Product 753	10,83%	3	0,36%	26,38%	A	Big
Product 758	11,04%	3	0,36%	26,74%	A	Big
Product 510	11,25%	3	0,36%	27,10%	A	Big
Product 771	11,46%	3	0,36%	27,46%	A	Big
Product 781	11,68%	3	0,36%	27,82%	A	Big
Product 1773	11,89%	3	0,36%	28,18%	A	Big
Product 493	12,10%	3	0,36%	28,54%	A	Big
Product 482	12,31%	3	0,36%	28,90%	A	Big
Product 473	12,53%	3	0,36%	29,26%	A	Big
Product 791	12,74%	3	0,36%	29,62%	A	Big
Product 792	12,95%	3	0,36%	29,98%	A	Big
Product 458	13,16%	3	0,36%	30,34%	A	Big
Product 797	13,38%	3	0,36%	30,70%	A	Big
Product 384	13,59%	3	0,36%	31,06%	A	Big
Product 825	13,80%	3	0,36%	31,41%	A	Big
Product 822	14,01%	3	0,36%	31,77%	A	Big
Product 815	14,23%	3	0,36%	32,13%	A	Big
Product 1389	14,44%	3	0,36%	32,49%	A	Big
Product 245	14,65%	3	0,36%	32,85%	A	Big
Product 214	14,86%	3	0,36%	33,21%	A	Big
Product 212	15,07%	3	0,36%	33,57%	A	Big
Product 867	15,29%	3	0,36%	33,93%	A	Big
Product 112	15,50%	3	0,36%	34,29%	A	Big
Product 81	15,71%	3	0,36%	34,65%	A	Big
Product 65	15,92%	3	0,36%	35,01%	A	Big
Product 35	16,14%	3	0,36%	35,37%	A	Big
Product 1964	16,35%	3	0,36%	35,73%	A	Medium
Product 1948	16,56%	3	0,36%	36,09%	A	Medium
Product 1947	16,77%	3	0,36%	36,45%	A	Medium
Product 2018	16,99%	3	0,36%	36,81%	A	Medium
Product 1824	17,20%	3	0,36%	37,17%	A	Medium
Product 1692	17,41%	3	0,36%	37,53%	A	Medium
Product 892	17,62%	3	0,36%	37,89%	A	Medium
Product 1576	17,83%	3	0,36%	38,25%	A	Medium

Product 1543	18,05%	3	0,36%	38,61%	A	Medium
Product 1489	18,26%	3	0,36%	38,97%	A	Medium
Product 739	18,47%	2	0,24%	39,21%	B	Big
Product 665	18,68%	2	0,24%	39,45%	B	Big
Product 700	18,90%	2	0,24%	39,69%	B	Big
Product 705	19,11%	2	0,24%	39,93%	B	Big
Product 2031	19,32%	2	0,24%	40,17%	B	Big
Product 710	19,53%	2	0,24%	40,41%	B	Big
Product 627	19,75%	2	0,24%	40,65%	B	Big
Product 711	19,96%	2	0,24%	40,89%	B	Big
Product 712	20,17%	2	0,24%	41,13%	B	Big
Product 713	20,38%	2	0,24%	41,37%	B	Big
Product 624	20,59%	2	0,24%	41,61%	B	Big
Product 623	20,81%	2	0,24%	41,85%	B	Big
Product 717	21,02%	2	0,24%	42,09%	B	Big
Product 720	21,23%	2	0,24%	42,33%	B	Big
Product 2001	21,44%	2	0,24%	42,57%	B	Big
Product 722	21,66%	2	0,24%	42,81%	B	Big
Product 724	21,87%	2	0,24%	43,05%	B	Big
Product 600	22,08%	2	0,24%	43,29%	B	Big
Product 559	22,29%	2	0,24%	43,53%	B	Big
Product 743	22,51%	2	0,24%	43,76%	B	Big
Product 744	22,72%	2	0,24%	44,00%	B	Big
Product 1857	22,93%	2	0,24%	44,24%	B	Big
Product 1853	23,14%	2	0,24%	44,48%	B	Big
Product 749	23,35%	2	0,24%	44,72%	B	Big
Product 748	23,57%	2	0,24%	44,96%	B	Big
Product 750	23,78%	2	0,24%	45,20%	B	Big
Product 751	23,99%	2	0,24%	45,44%	B	Big
Product 1860	24,20%	2	0,24%	45,68%	B	Big
Product 1855	24,42%	2	0,24%	45,92%	B	Big
Product 763	24,63%	2	0,24%	46,16%	B	Big
Product 765	24,84%	2	0,24%	46,40%	B	Big
Product 520	25,05%	2	0,24%	46,64%	B	Big
Product 501	25,27%	2	0,24%	46,88%	B	Big
Product 778	25,48%	2	0,24%	47,12%	B	Big
Product 770	25,69%	2	0,24%	47,36%	B	Big
Product 772	25,90%	2	0,24%	47,60%	B	Big
Product 774	26,11%	2	0,24%	47,84%	B	Big
Product 769	26,33%	2	0,24%	48,08%	B	Big
Product 1767	26,54%	2	0,24%	48,32%	B	Big
Product 490	26,75%	2	0,24%	48,56%	B	Big
Product 790	26,96%	2	0,24%	48,80%	B	Big
Product 1709	27,18%	2	0,24%	49,04%	B	Big
Product 1719	27,39%	2	0,24%	49,28%	B	Big

Product 456	27,60%	2	0,24%	49,52%	B	Big
Product 439	27,81%	2	0,24%	49,76%	B	Big
Product 435	28,03%	2	0,24%	50,00%	B	Big
Product 1646	28,24%	2	0,24%	50,24%	B	Big
Product 802	28,45%	2	0,24%	50,48%	B	Big
Product 805	28,66%	2	0,24%	50,72%	B	Big
Product 1622	28,87%	2	0,24%	50,96%	B	Big
Product 426	29,09%	2	0,24%	51,20%	B	Big
Product 416	29,30%	2	0,24%	51,44%	B	Big
Product 403	29,51%	2	0,24%	51,68%	B	Big
Product 381	29,72%	2	0,24%	51,92%	B	Big
Product 821	29,94%	2	0,24%	52,16%	B	Big
Product 820	30,15%	2	0,24%	52,40%	B	Big
Product 823	30,36%	2	0,24%	52,64%	B	Big
Product 824	30,57%	2	0,24%	52,88%	B	Big
Product 345	30,79%	2	0,24%	53,12%	B	Big
Product 340	31,00%	2	0,24%	53,36%	B	Big
Product 335	31,21%	2	0,24%	53,60%	B	Big
Product 332	31,42%	2	0,24%	53,84%	B	Big
Product 847	31,63%	2	0,24%	54,08%	B	Big
Product 838	31,85%	2	0,24%	54,32%	B	Big
Product 831	32,06%	2	0,24%	54,56%	B	Big
Product 840	32,27%	2	0,24%	54,80%	B	Big
Product 839	32,48%	2	0,24%	55,04%	B	Big
Product 1382	32,70%	2	0,24%	55,28%	B	Big
Product 322	32,91%	2	0,24%	55,52%	B	Big
Product 318	33,12%	2	0,24%	55,76%	B	Big
Product 313	33,33%	2	0,24%	56,00%	B	Big
Product 284	33,55%	2	0,24%	56,24%	B	Big
Product 275	33,76%	2	0,24%	56,47%	B	Big
Product 265	33,97%	2	0,24%	56,71%	B	Big
Product 255	34,18%	2	0,24%	56,95%	B	Big
Product 252	34,39%	2	0,24%	57,19%	B	Big
Product 210	34,61%	2	0,24%	57,43%	B	Big
Product 859	34,82%	2	0,24%	57,67%	B	Big
Product 857	35,03%	2	0,24%	57,91%	B	Big
Product 853	35,24%	2	0,24%	58,15%	B	Big
Product 860	35,46%	2	0,24%	58,39%	B	Big
Product 863	35,67%	2	0,24%	58,63%	B	Big
Product 862	35,88%	2	0,24%	58,87%	B	Big
Product 196	36,09%	2	0,24%	59,11%	B	Big
Product 189	36,31%	2	0,24%	59,35%	B	Big
Product 169	36,52%	2	0,24%	59,59%	B	Big
Product 162	36,73%	2	0,24%	59,83%	B	Big
Product 156	36,94%	2	0,24%	60,07%	B	Big

Product 155	37,15%	2	0,24%	60,31%	B	Big
Product 110	37,37%	2	0,24%	60,55%	B	Big
Product 89	37,58%	2	0,24%	60,79%	B	Big
Product 73	37,79%	2	0,24%	61,03%	B	Big
Product 2045	38,00%	2	0,24%	61,27%	B	Medium
Product 2107	38,22%	2	0,24%	61,51%	B	Medium
Product 1992	38,43%	2	0,24%	61,75%	B	Medium
Product 2010	38,64%	2	0,24%	61,99%	B	Medium
Product 1977	38,85%	2	0,24%	62,23%	B	Medium
Product 1972	39,07%	2	0,24%	62,47%	B	Medium
Product 1966	39,28%	2	0,24%	62,71%	B	Medium
Product 1944	39,49%	2	0,24%	62,95%	B	Medium
Product 2019	39,70%	2	0,24%	63,19%	B	Medium
Product 1872	39,92%	2	0,24%	63,43%	B	Medium
Product 2028	40,13%	2	0,24%	63,67%	B	Medium
Product 2029	40,34%	2	0,24%	63,91%	B	Medium
Product 1866	40,55%	2	0,24%	64,15%	B	Medium
Product 1836	40,76%	2	0,24%	64,39%	B	Medium
Product 2054	40,98%	2	0,24%	64,63%	B	Medium
Product 1250	41,19%	2	0,24%	64,87%	B	Medium
Product 1739	41,40%	2	0,24%	65,11%	B	Medium
Product 1734	41,61%	2	0,24%	65,35%	B	Medium
Product 1694	41,83%	2	0,24%	65,59%	B	Medium
Product 2108	42,04%	2	0,24%	65,83%	B	Medium
Product 1664	42,25%	2	0,24%	66,07%	B	Medium
Product 2121	42,46%	2	0,24%	66,31%	B	Medium
Product 1581	42,68%	2	0,24%	66,55%	B	Medium
Product 1560	42,89%	2	0,24%	66,79%	B	Medium
Product 1544	43,10%	2	0,24%	67,03%	B	Medium
Product 1494	43,31%	2	0,24%	67,27%	B	Medium
Product 686	43,52%	2	0,24%	67,51%	B	Medium
Product 695	43,74%	2	0,24%	67,75%	B	Medium
Product 2316	43,95%	2	0,24%	67,99%	B	Small
Product 2258	44,16%	2	0,24%	68,23%	B	Small
Product 2133	44,37%	2	0,24%	68,47%	B	Small
Product 2132	44,59%	2	0,24%	68,71%	B	Small
Product 742	44,80%	1	0,12%	68,82%	C	Big
Product 783	45,01%	1	0,12%	68,94%	C	Big
Product 668	45,22%	1	0,12%	69,06%	C	Big
Product 674	45,44%	1	0,12%	69,18%	C	Big
Product 675	45,65%	1	0,12%	69,30%	C	Big
Product 677	45,86%	1	0,12%	69,42%	C	Big
Product 678	46,07%	1	0,12%	69,54%	C	Big
Product 680	46,28%	1	0,12%	69,66%	C	Big
Product 681	46,50%	1	0,12%	69,78%	C	Big

Product 682	46,71%	1	0,12%	69,90%	C	Big
Product 2068	46,92%	1	0,12%	70,02%	C	Big
Product 646	47,13%	1	0,12%	70,14%	C	Big
Product 701	47,35%	1	0,12%	70,26%	C	Big
Product 702	47,56%	1	0,12%	70,38%	C	Big
Product 704	47,77%	1	0,12%	70,50%	C	Big
Product 703	47,98%	1	0,12%	70,62%	C	Big
Product 706	48,20%	1	0,12%	70,74%	C	Big
Product 2038	48,41%	1	0,12%	70,86%	C	Big
Product 2040	48,62%	1	0,12%	70,98%	C	Big
Product 629	48,83%	1	0,12%	71,10%	C	Big
Product 2030	49,04%	1	0,12%	71,22%	C	Big
Product 709	49,26%	1	0,12%	71,34%	C	Big
Product 626	49,47%	1	0,12%	71,46%	C	Big
Product 715	49,68%	1	0,12%	71,58%	C	Big
Product 714	49,89%	1	0,12%	71,70%	C	Big
Product 716	50,11%	1	0,12%	71,82%	C	Big
Product 2017	50,32%	1	0,12%	71,94%	C	Big
Product 719	50,53%	1	0,12%	72,06%	C	Big
Product 718	50,74%	1	0,12%	72,18%	C	Big
Product 609	50,96%	1	0,12%	72,30%	C	Big
Product 607	51,17%	1	0,12%	72,42%	C	Big
Product 1985	51,38%	1	0,12%	72,54%	C	Big
Product 725	51,59%	1	0,12%	72,66%	C	Big
Product 726	51,80%	1	0,12%	72,78%	C	Big
Product 733	52,02%	1	0,12%	72,90%	C	Big
Product 587	52,23%	1	0,12%	73,02%	C	Big
Product 586	52,44%	1	0,12%	73,14%	C	Big
Product 581	52,65%	1	0,12%	73,26%	C	Big
Product 580	52,87%	1	0,12%	73,38%	C	Big
Product 577	53,08%	1	0,12%	73,50%	C	Big
Product 734	53,29%	1	0,12%	73,62%	C	Big
Product 735	53,50%	1	0,12%	73,74%	C	Big
Product 573	53,72%	1	0,12%	73,86%	C	Big
Product 566	53,93%	1	0,12%	73,98%	C	Big
Product 555	54,14%	1	0,12%	74,10%	C	Big
Product 1884	54,35%	1	0,12%	74,22%	C	Big
Product 740	54,56%	1	0,12%	74,34%	C	Big
Product 738	54,78%	1	0,12%	74,46%	C	Big
Product 745	54,99%	1	0,12%	74,58%	C	Big
Product 551	55,20%	1	0,12%	74,70%	C	Big
Product 755	55,41%	1	0,12%	74,82%	C	Big
Product 754	55,63%	1	0,12%	74,94%	C	Big
Product 747	55,84%	1	0,12%	75,06%	C	Big
Product 752	56,05%	1	0,12%	75,18%	C	Big

Product 757	56,26%	1	0,12%	75,30%	C	Big
Product 756	56,48%	1	0,12%	75,42%	C	Big
Product 542	56,69%	1	0,12%	75,54%	C	Big
Product 532	56,90%	1	0,12%	75,66%	C	Big
Product 764	57,11%	1	0,12%	75,78%	C	Big
Product 761	57,32%	1	0,12%	75,90%	C	Big
Product 760	57,54%	1	0,12%	76,02%	C	Big
Product 759	57,75%	1	0,12%	76,14%	C	Big
Product 762	57,96%	1	0,12%	76,26%	C	Big
Product 766	58,17%	1	0,12%	76,38%	C	Big
Product 517	58,39%	1	0,12%	76,50%	C	Big
Product 515	58,60%	1	0,12%	76,62%	C	Big
Product 509	58,81%	1	0,12%	76,74%	C	Big
Product 500	59,02%	1	0,12%	76,86%	C	Big
Product 498	59,24%	1	0,12%	76,98%	C	Big
Product 776	59,45%	1	0,12%	77,10%	C	Big
Product 773	59,66%	1	0,12%	77,22%	C	Big
Product 1769	59,87%	1	0,12%	77,34%	C	Big
Product 1775	60,08%	1	0,12%	77,46%	C	Big
Product 779	60,30%	1	0,12%	77,58%	C	Big
Product 768	60,51%	1	0,12%	77,70%	C	Big
Product 767	60,72%	1	0,12%	77,82%	C	Big
Product 780	60,93%	1	0,12%	77,94%	C	Big
Product 782	61,15%	1	0,12%	78,06%	C	Big
Product 784	61,36%	1	0,12%	78,18%	C	Big
Product 496	61,57%	1	0,12%	78,30%	C	Big
Product 495	61,78%	1	0,12%	78,42%	C	Big
Product 489	62,00%	1	0,12%	78,54%	C	Big
Product 477	62,21%	1	0,12%	78,66%	C	Big
Product 474	62,42%	1	0,12%	78,78%	C	Big
Product 1731	62,63%	1	0,12%	78,90%	C	Big
Product 785	62,85%	1	0,12%	79,02%	C	Big
Product 1705	63,06%	1	0,12%	79,14%	C	Big
Product 787	63,27%	1	0,12%	79,26%	C	Big
Product 789	63,48%	1	0,12%	79,38%	C	Big
Product 786	63,69%	1	0,12%	79,50%	C	Big
Product 793	63,91%	1	0,12%	79,62%	C	Big
Product 794	64,12%	1	0,12%	79,74%	C	Big
Product 467	64,33%	1	0,12%	79,86%	C	Big
Product 465	64,54%	1	0,12%	79,98%	C	Big
Product 457	64,76%	1	0,12%	80,10%	C	Big
Product 434	64,97%	1	0,12%	80,22%	C	Big
Product 432	65,18%	1	0,12%	80,34%	C	Big
Product 431	65,39%	1	0,12%	80,46%	C	Big
Product 800	65,61%	1	0,12%	80,58%	C	Big

Product 1645	65,82%	1	0,12%	80,70%	C	Big
Product 1627	66,03%	1	0,12%	80,82%	C	Big
Product 801	66,24%	1	0,12%	80,94%	C	Big
Product 798	66,45%	1	0,12%	81,06%	C	Big
Product 804	66,67%	1	0,12%	81,18%	C	Big
Product 803	66,88%	1	0,12%	81,29%	C	Big
Product 1617	67,09%	1	0,12%	81,41%	C	Big
Product 807	67,30%	1	0,12%	81,53%	C	Big
Product 808	67,52%	1	0,12%	81,65%	C	Big
Product 809	67,73%	1	0,12%	81,77%	C	Big
Product 1624	67,94%	1	0,12%	81,89%	C	Big
Product 412	68,15%	1	0,12%	82,01%	C	Big
Product 390	68,37%	1	0,12%	82,13%	C	Big
Product 387	68,58%	1	0,12%	82,25%	C	Big
Product 382	68,79%	1	0,12%	82,37%	C	Big
Product 817	69,00%	1	0,12%	82,49%	C	Big
Product 1502	69,21%	1	0,12%	82,61%	C	Big
Product 816	69,43%	1	0,12%	82,73%	C	Big
Product 819	69,64%	1	0,12%	82,85%	C	Big
Product 814	69,85%	1	0,12%	82,97%	C	Big
Product 812	70,06%	1	0,12%	83,09%	C	Big
Product 828	70,28%	1	0,12%	83,21%	C	Big
Product 1516	70,49%	1	0,12%	83,33%	C	Big
Product 1498	70,70%	1	0,12%	83,45%	C	Big
Product 826	70,91%	1	0,12%	83,57%	C	Big
Product 827	71,13%	1	0,12%	83,69%	C	Big
Product 829	71,34%	1	0,12%	83,81%	C	Big
Product 373	71,55%	1	0,12%	83,93%	C	Big
Product 356	71,76%	1	0,12%	84,05%	C	Big
Product 338	71,97%	1	0,12%	84,17%	C	Big
Product 336	72,19%	1	0,12%	84,29%	C	Big
Product 324	72,40%	1	0,12%	84,41%	C	Big
Product 841	72,61%	1	0,12%	84,53%	C	Big
Product 849	72,82%	1	0,12%	84,65%	C	Big
Product 1377	73,04%	1	0,12%	84,77%	C	Big
Product 835	73,25%	1	0,12%	84,89%	C	Big
Product 832	73,46%	1	0,12%	85,01%	C	Big
Product 833	73,67%	1	0,12%	85,13%	C	Big
Product 836	73,89%	1	0,12%	85,25%	C	Big
Product 837	74,10%	1	0,12%	85,37%	C	Big
Product 1376	74,31%	1	0,12%	85,49%	C	Big
Product 842	74,52%	1	0,12%	85,61%	C	Big
Product 1391	74,73%	1	0,12%	85,73%	C	Big
Product 843	74,95%	1	0,12%	85,85%	C	Big
Product 848	75,16%	1	0,12%	85,97%	C	Big

Product 834	75,37%	1	0,12%	86,09%	C	Big
Product 845	75,58%	1	0,12%	86,21%	C	Big
Product 844	75,80%	1	0,12%	86,33%	C	Big
Product 1371	76,01%	1	0,12%	86,45%	C	Big
Product 846	76,22%	1	0,12%	86,57%	C	Big
Product 312	76,43%	1	0,12%	86,69%	C	Big
Product 310	76,65%	1	0,12%	86,81%	C	Big
Product 308	76,86%	1	0,12%	86,93%	C	Big
Product 266	77,07%	1	0,12%	87,05%	C	Big
Product 260	77,28%	1	0,12%	87,17%	C	Big
Product 257	77,49%	1	0,12%	87,29%	C	Big
Product 256	77,71%	1	0,12%	87,41%	C	Big
Product 253	77,92%	1	0,12%	87,53%	C	Big
Product 251	78,13%	1	0,12%	87,65%	C	Big
Product 248	78,34%	1	0,12%	87,77%	C	Big
Product 244	78,56%	1	0,12%	87,89%	C	Big
Product 230	78,77%	1	0,12%	88,01%	C	Big
Product 229	78,98%	1	0,12%	88,13%	C	Big
Product 209	79,19%	1	0,12%	88,25%	C	Big
Product 208	79,41%	1	0,12%	88,37%	C	Big
Product 871	79,62%	1	0,12%	88,49%	C	Big
Product 1108	79,83%	1	0,12%	88,61%	C	Big
Product 861	80,04%	1	0,12%	88,73%	C	Big
Product 856	80,25%	1	0,12%	88,85%	C	Big
Product 854	80,47%	1	0,12%	88,97%	C	Big
Product 865	80,68%	1	0,12%	89,09%	C	Big
Product 864	80,89%	1	0,12%	89,21%	C	Big
Product 851	81,10%	1	0,12%	89,33%	C	Big
Product 866	81,32%	1	0,12%	89,45%	C	Big
Product 1120	81,53%	1	0,12%	89,57%	C	Big
Product 852	81,74%	1	0,12%	89,69%	C	Big
Product 855	81,95%	1	0,12%	89,81%	C	Big
Product 868	82,17%	1	0,12%	89,93%	C	Big
Product 869	82,38%	1	0,12%	90,05%	C	Big
Product 870	82,59%	1	0,12%	90,17%	C	Big
Product 200	82,80%	1	0,12%	90,29%	C	Big
Product 197	83,01%	1	0,12%	90,41%	C	Big
Product 190	83,23%	1	0,12%	90,53%	C	Big
Product 165	83,44%	1	0,12%	90,65%	C	Big
Product 129	83,65%	1	0,12%	90,77%	C	Big
Product 128	83,86%	1	0,12%	90,89%	C	Big
Product 95	84,08%	1	0,12%	91,01%	C	Big
Product 94	84,29%	1	0,12%	91,13%	C	Big
Product 83	84,50%	1	0,12%	91,25%	C	Big
Product 374	84,71%	1	0,12%	91,37%	C	Big

Product 2011	84,93%	1	0,12%	91,49%	C	Medium
Product 2022	85,14%	1	0,12%	91,61%	C	Medium
Product 2036	85,35%	1	0,12%	91,73%	C	Medium
Product 2044	85,56%	1	0,12%	91,85%	C	Medium
Product 2067	85,77%	1	0,12%	91,97%	C	Medium
Product 2069	85,99%	1	0,12%	92,09%	C	Medium
Product 2118	86,20%	1	0,12%	92,21%	C	Medium
Product 2127	86,41%	1	0,12%	92,33%	C	Medium
Product 2128	86,62%	1	0,12%	92,45%	C	Medium
Product 2126	86,84%	1	0,12%	92,57%	C	Medium
Product 2005	87,05%	1	0,12%	92,69%	C	Medium
Product 1998	87,26%	1	0,12%	92,81%	C	Medium
Product 1995	87,47%	1	0,12%	92,93%	C	Medium
Product 1980	87,69%	1	0,12%	93,05%	C	Medium
Product 1978	87,90%	1	0,12%	93,17%	C	Medium
Product 2012	88,11%	1	0,12%	93,29%	C	Medium
Product 1976	88,32%	1	0,12%	93,41%	C	Medium
Product 1970	88,54%	1	0,12%	93,53%	C	Medium
Product 2014	88,75%	1	0,12%	93,65%	C	Medium
Product 1943	88,96%	1	0,12%	93,76%	C	Medium
Product 1926	89,17%	1	0,12%	93,88%	C	Medium
Product 1925	89,38%	1	0,12%	94,00%	C	Medium
Product 1924	89,60%	1	0,12%	94,12%	C	Medium
Product 1920	89,81%	1	0,12%	94,24%	C	Medium
Product 1918	90,02%	1	0,12%	94,36%	C	Medium
Product 2023	90,23%	1	0,12%	94,48%	C	Medium
Product 2026	90,45%	1	0,12%	94,60%	C	Medium
Product 1873	90,66%	1	0,12%	94,72%	C	Medium
Product 1867	90,87%	1	0,12%	94,84%	C	Medium
Product 2037	91,08%	1	0,12%	94,96%	C	Medium
Product 2046	91,30%	1	0,12%	95,08%	C	Medium
Product 2047	91,51%	1	0,12%	95,20%	C	Medium
Product 1825	91,72%	1	0,12%	95,32%	C	Medium
Product 1299	91,93%	1	0,12%	95,44%	C	Medium
Product 1249	92,14%	1	0,12%	95,56%	C	Medium
Product 1789	92,36%	1	0,12%	95,68%	C	Medium
Product 2072	92,57%	1	0,12%	95,80%	C	Medium
Product 1174	92,78%	1	0,12%	95,92%	C	Medium
Product 2074	92,99%	1	0,12%	96,04%	C	Medium
Product 1753	93,21%	1	0,12%	96,16%	C	Medium
Product 1745	93,42%	1	0,12%	96,28%	C	Medium
Product 1740	93,63%	1	0,12%	96,40%	C	Medium
Product 1733	93,84%	1	0,12%	96,52%	C	Medium
Product 1702	94,06%	1	0,12%	96,64%	C	Medium
Product 1001	94,27%	1	0,12%	96,76%	C	Medium

Product 2109	94,48%	1	0,12%	96,88%	C	Medium
Product 1004	94,69%	1	0,12%	97,00%	C	Medium
Product 1671	94,90%	1	0,12%	97,12%	C	Medium
Product 1615	95,12%	1	0,12%	97,24%	C	Medium
Product 1611	95,33%	1	0,12%	97,36%	C	Medium
Product 2119	95,54%	1	0,12%	97,48%	C	Medium
Product 2120	95,75%	1	0,12%	97,60%	C	Medium
Product 1602	95,97%	1	0,12%	97,72%	C	Medium
Product 1574	96,18%	1	0,12%	97,84%	C	Medium
Product 1562	96,39%	1	0,12%	97,96%	C	Medium
Product 1550	96,60%	1	0,12%	98,08%	C	Medium
Product 1487	96,82%	1	0,12%	98,20%	C	Medium
Product 1486	97,03%	1	0,12%	98,32%	C	Medium
Product 1476	97,24%	1	0,12%	98,44%	C	Medium
Product 1461	97,45%	1	0,12%	98,56%	C	Medium
Product 693	97,66%	1	0,12%	98,68%	C	Medium
Product 694	97,88%	1	0,12%	98,80%	C	Medium
Product 683	98,09%	1	0,12%	98,92%	C	Medium
Product 1450	98,30%	1	0,12%	99,04%	C	Medium
Product 1309	98,51%	1	0,12%	99,16%	C	Medium
Product 1247	98,73%	1	0,12%	99,28%	C	Medium
Product 1045	98,94%	1	0,12%	99,40%	C	Medium
Product 1485	99,15%	1	0,12%	99,52%	C	Medium
Product 2377	99,36%	1	0,12%	99,64%	C	Small
Product 2379	99,58%	1	0,12%	99,76%	C	Small
Product 2354	99,79%	1	0,12%	99,88%	C	Small
Product 2278	100,00%	1	0,12%	100,00%	C	Small

Appendix Z – ABC Analysis: ESKU Family

SKU	%	Picking Frequency			Class	Sub-Family
		Picks	%	Cumulative		
Product 2380	0,73%	27	6,19%	6,19%	A	Medium
Product 2381	1,46%	22	5,05%	11,24%	A	Medium
Product 2382	2,19%	18	4,13%	15,37%	A	Medium
Product 2383	2,92%	13	2,98%	18,35%	A	Medium
Product 2384	3,65%	12	2,75%	21,10%	A	Medium
Product 2385	4,38%	12	2,75%	23,85%	A	Medium
Product 2386	5,11%	10	2,29%	26,15%	A	Medium
Product 2387	5,84%	10	2,29%	28,44%	A	Medium
Product 2388	6,57%	8	1,83%	30,28%	A	Medium
Product 3189	7,30%	7	1,61%	31,88%	A	Medium
Product 2389	8,03%	7	1,61%	33,49%	A	Medium
Product 2390	8,76%	6	1,38%	34,86%	A	Medium
Product 2391	9,49%	6	1,38%	36,24%	A	Medium
Product 2393	10,22%	6	1,38%	37,61%	A	Medium
Product 2392	10,95%	6	1,38%	38,99%	A	Medium
Product 2394	11,68%	6	1,38%	40,37%	A	Medium
Product 2395	12,41%	6	1,38%	41,74%	A	Medium
Product 2396	13,14%	6	1,38%	43,12%	A	Medium
Product 2397	13,87%	6	1,38%	44,50%	A	Medium
Product 2403	14,60%	5	1,15%	45,64%	A	Medium
Product 2400	15,33%	5	1,15%	46,79%	A	Medium
Product 2402	16,06%	5	1,15%	47,94%	A	Medium
Product 2399	16,79%	5	1,15%	49,08%	A	Medium
Product 2398	17,52%	5	1,15%	50,23%	A	Medium
Product 2401	18,25%	5	1,15%	51,38%	A	Medium
Product 2404	18,98%	5	1,15%	52,52%	A	Medium
Product 2405	19,71%	5	1,15%	53,67%	A	Medium
Product 3148	20,44%	4	0,92%	54,59%	A	Medium
Product 2414	21,17%	4	0,92%	55,50%	A	Medium
Product 2408	21,90%	4	0,92%	56,42%	A	Medium
Product 2406	22,63%	4	0,92%	57,34%	A	Medium
Product 2407	23,36%	4	0,92%	58,26%	A	Medium
Product 2415	24,09%	4	0,92%	59,17%	A	Medium
Product 2410	24,82%	4	0,92%	60,09%	A	Medium
Product 2409	25,55%	4	0,92%	61,01%	B	Medium
Product 2411	26,28%	4	0,92%	61,93%	B	Medium
Product 2412	27,01%	4	0,92%	62,84%	B	Medium
Product 2413	27,74%	4	0,92%	63,76%	B	Medium
Product 2416	28,47%	4	0,92%	64,68%	B	Medium
Product 2636	29,20%	4	0,92%	65,60%	B	Medium
Product 2417	29,93%	4	0,92%	66,51%	B	Medium
Product 2418	30,66%	4	0,92%	67,43%	B	Medium
Product 2419	31,39%	3	0,69%	68,12%	B	Medium

Product 2420	32,12%	3	0,69%	68,81%	B	Medium
Product 2421	32,85%	3	0,69%	69,50%	B	Medium
Product 2422	33,58%	3	0,69%	70,18%	B	Medium
Product 2423	34,31%	3	0,69%	70,87%	B	Medium
Product 2974	35,04%	3	0,69%	71,56%	B	Medium
Product 2434	35,77%	2	0,46%	72,02%	B	Medium
Product 2428	36,50%	2	0,46%	72,48%	B	Medium
Product 2426	37,23%	2	0,46%	72,94%	B	Medium
Product 2492	37,96%	2	0,46%	73,39%	B	Medium
Product 3143	38,69%	2	0,46%	73,85%	B	Medium
Product 2429	39,42%	2	0,46%	74,31%	B	Medium
Product 2430	40,15%	2	0,46%	74,77%	B	Medium
Product 2424	40,88%	2	0,46%	75,23%	B	Medium
Product 2433	41,61%	2	0,46%	75,69%	B	Medium
Product 3163	42,34%	2	0,46%	76,15%	B	Medium
Product 2437	43,07%	2	0,46%	76,61%	B	Medium
Product 2436	43,80%	2	0,46%	77,06%	B	Medium
Product 3135	44,53%	2	0,46%	77,52%	B	Medium
Product 2425	45,26%	2	0,46%	77,98%	B	Medium
Product 2427	45,99%	2	0,46%	78,44%	B	Medium
Product 2431	46,72%	2	0,46%	78,90%	B	Medium
Product 2432	47,45%	2	0,46%	79,36%	B	Medium
Product 2435	48,18%	2	0,46%	79,82%	B	Medium
Product 2884	48,91%	2	0,46%	80,28%	B	Medium
Product 2530	49,64%	2	0,46%	80,73%	B	Medium
Product 2438	50,36%	2	0,46%	81,19%	B	Medium
Product 2548	51,09%	2	0,46%	81,65%	B	Medium
Product 2439	51,82%	2	0,46%	82,11%	B	Medium
Product 2440	52,55%	2	0,46%	82,57%	B	Medium
Product 2441	53,28%	2	0,46%	83,03%	B	Medium
Product 2442	54,01%	2	0,46%	83,49%	B	Medium
Product 2443	54,74%	2	0,46%	83,94%	B	Medium
Product 2444	55,47%	2	0,46%	84,40%	B	Medium
Product 2445	56,20%	2	0,46%	84,86%	B	Medium
Product 3044	56,93%	2	0,46%	85,32%	B	Medium
Product 2857	57,66%	2	0,46%	85,78%	C	Medium
Product 2446	58,39%	2	0,46%	86,24%	C	Medium
Product 2573	59,12%	2	0,46%	86,70%	C	Medium
Product 3203	59,85%	2	0,46%	87,16%	C	Medium
Product 2447	60,58%	2	0,46%	87,61%	C	Medium
Product 2460	61,31%	1	0,23%	87,84%	C	Medium
Product 3204	62,04%	1	0,23%	88,07%	C	Medium
Product 2448	62,77%	1	0,23%	88,30%	C	Medium
Product 2464	63,50%	1	0,23%	88,53%	C	Medium
Product 2465	64,23%	1	0,23%	88,76%	C	Medium
Product 2452	64,96%	1	0,23%	88,99%	C	Medium
Product 2450	65,69%	1	0,23%	89,22%	C	Medium
Product 3178	66,42%	1	0,23%	89,45%	C	Medium

Product 2451	67,15%	1	0,23%	89,68%	C	Medium
Product 2459	67,88%	1	0,23%	89,91%	C	Medium
Product 2456	68,61%	1	0,23%	90,14%	C	Medium
Product 2458	69,34%	1	0,23%	90,37%	C	Medium
Product 2463	70,07%	1	0,23%	90,60%	C	Medium
Product 2471	70,80%	1	0,23%	90,83%	C	Medium
Product 2449	71,53%	1	0,23%	91,06%	C	Medium
Product 2454	72,26%	1	0,23%	91,28%	C	Medium
Product 2455	72,99%	1	0,23%	91,51%	C	Medium
Product 2466	73,72%	1	0,23%	91,74%	C	Medium
Product 2467	74,45%	1	0,23%	91,97%	C	Medium
Product 2468	75,18%	1	0,23%	92,20%	C	Medium
Product 2469	75,91%	1	0,23%	92,43%	C	Medium
Product 2470	76,64%	1	0,23%	92,66%	C	Medium
Product 2472	77,37%	1	0,23%	92,89%	C	Medium
Product 2473	78,10%	1	0,23%	93,12%	C	Medium
Product 2474	78,83%	1	0,23%	93,35%	C	Medium
Product 2475	79,56%	1	0,23%	93,58%	C	Medium
Product 2453	80,29%	1	0,23%	93,81%	C	Medium
Product 2457	81,02%	1	0,23%	94,04%	C	Medium
Product 2461	81,75%	1	0,23%	94,27%	C	Medium
Product 2462	82,48%	1	0,23%	94,50%	C	Medium
Product 2574	83,21%	1	0,23%	94,72%	C	Medium
Product 3181	83,94%	1	0,23%	94,95%	C	Medium
Product 3193	84,67%	1	0,23%	95,18%	C	Medium
Product 2483	85,40%	1	0,23%	95,41%	C	Medium
Product 2482	86,13%	1	0,23%	95,64%	C	Medium
Product 2975	86,86%	1	0,23%	95,87%	C	Medium
Product 2484	87,59%	1	0,23%	96,10%	C	Medium
Product 2476	88,32%	1	0,23%	96,33%	C	Medium
Product 2477	89,05%	1	0,23%	96,56%	C	Medium
Product 2478	89,78%	1	0,23%	96,79%	C	Medium
Product 2479	90,51%	1	0,23%	97,02%	C	Medium
Product 2480	91,24%	1	0,23%	97,25%	C	Medium
Product 2481	91,97%	1	0,23%	97,48%	C	Medium
Product 3136	92,70%	1	0,23%	97,71%	C	Medium
Product 2620	93,43%	1	0,23%	97,94%	C	Medium
Product 3137	94,16%	1	0,23%	98,17%	C	Medium
Product 3164	94,89%	1	0,23%	98,39%	C	Medium
Product 2776	95,62%	1	0,23%	98,62%	C	Medium
Product 2485	96,35%	1	0,23%	98,85%	C	Medium
Product 2486	97,08%	1	0,23%	99,08%	C	Medium
Product 2934	97,81%	1	0,23%	99,31%	C	Medium
Product 2487	98,54%	1	0,23%	99,54%	C	Medium
Product 2488	99,27%	1	0,23%	99,77%	C	Medium
Product 3199	100,00%	1	0,23%	100,00%	C	Medium

Appendix AA – ABC Analysis: FAI Family

SKU	%	Picking Frequency			Class	Sub-Family
		Picks	%	Cumulative		
Product 106	1%	2	1,90%	1,90%	A	Big
Product 2125	2%	2	1,90%	3,81%	A	Medium
Product 2111	3%	2	1,90%	5,71%	A	Medium
Product 2075	4%	2	1,90%	7,62%	A	Medium
Product 2056	5%	2	1,90%	9,52%	A	Medium
Product 850	6%	1	0,95%	10,48%	A	Big
Product 589	7%	1	0,95%	11,43%	A	Big
Product 795	8%	1	0,95%	12,38%	A	Big
Product 796	9%	1	0,95%	13,33%	A	Big
Product 572	10%	1	0,95%	14,29%	A	Big
Product 810	11%	1	0,95%	15,24%	A	Big
Product 447	12%	1	0,95%	16,19%	A	Big
Product 830	13%	1	0,95%	17,14%	A	Big
Product 605	14%	1	0,95%	18,10%	A	Big
Product 575	15%	1	0,95%	19,05%	A	Big
Product 549	16%	1	0,95%	20,00%	A	Big
Product 523	17%	1	0,95%	20,95%	A	Big
Product 396	18%	1	0,95%	21,90%	A	Big
Product 483	19%	1	0,95%	22,86%	A	Big
Product 438	20%	1	0,95%	23,81%	A	Big
Product 194	21%	1	0,95%	24,76%	A	Big
Product 525	22%	1	0,95%	25,71%	A	Big
Product 811	23%	1	0,95%	26,67%	A	Big
Product 411	24%	1	0,95%	27,62%	A	Big
Product 144	25%	1	0,95%	28,57%	A	Big
Product 139	26%	1	0,95%	29,52%	A	Big
Product 149	27%	1	0,95%	30,48%	A	Big
Product 872	28%	1	0,95%	31,43%	A	Big
Product 2130	29%	1	0,95%	32,38%	B	Medium
Product 1226	30%	1	0,95%	33,33%	B	Medium
Product 1810	31%	1	0,95%	34,29%	B	Medium
Product 1653	32%	1	0,95%	35,24%	B	Medium
Product 2034	33%	1	0,95%	36,19%	B	Medium
Product 2021	34%	1	0,95%	37,14%	B	Medium
Product 2015	35%	1	0,95%	38,10%	B	Medium
Product 2110	36%	1	0,95%	39,05%	B	Medium
Product 2124	37%	1	0,95%	40,00%	B	Medium
Product 2035	38%	1	0,95%	40,95%	B	Medium
Product 2051	39%	1	0,95%	41,90%	B	Medium
Product 2033	40%	1	0,95%	42,86%	B	Medium
Product 2117	41%	1	0,95%	43,81%	B	Medium
Product 2116	42%	1	0,95%	44,76%	B	Medium
Product 1415	43%	1	0,95%	45,71%	B	Medium

Product 2016	44%	1	0,95%	46,67%	B	Medium
Product 2048	45%	1	0,95%	47,62%	B	Medium
Product 2092	46%	1	0,95%	48,57%	B	Medium
Product 1784	47%	1	0,95%	49,52%	B	Medium
Product 2020	48%	1	0,95%	50,48%	B	Medium
Product 2123	49%	1	0,95%	51,43%	B	Medium
Product 2122	50%	1	0,95%	52,38%	B	Medium
Product 2083	51%	1	0,95%	53,33%	B	Medium
Product 2076	52%	1	0,95%	54,29%	B	Medium
Product 2089	53%	1	0,95%	55,24%	B	Medium
Product 2103	54%	1	0,95%	56,19%	B	Medium
Product 2098	55%	1	0,95%	57,14%	B	Medium
Product 2065	56%	1	0,95%	58,10%	B	Medium
Product 2082	57%	1	0,95%	59,05%	B	Medium
Product 2055	58%	1	0,95%	60,00%	B	Medium
Product 2097	59%	1	0,95%	60,95%	C	Medium
Product 2079	60%	1	0,95%	61,90%	C	Medium
Product 1665	61%	1	0,95%	62,86%	C	Medium
Product 2091	62%	1	0,95%	63,81%	C	Medium
Product 2093	63%	1	0,95%	64,76%	C	Medium
Product 2088	64%	1	0,95%	65,71%	C	Medium
Product 2032	65%	1	0,95%	66,67%	C	Medium
Product 2013	66%	1	0,95%	67,62%	C	Medium
Product 2006	67%	1	0,95%	68,57%	C	Medium
Product 2090	68%	1	0,95%	69,52%	C	Medium
Product 2105	69%	1	0,95%	70,48%	C	Medium
Product 2061	70%	1	0,95%	71,43%	C	Medium
Product 2129	71%	1	0,95%	72,38%	C	Medium
Product 2077	72%	1	0,95%	73,33%	C	Medium
Product 2104	73%	1	0,95%	74,29%	C	Medium
Product 1808	74%	1	0,95%	75,24%	C	Medium
Product 1760	75%	1	0,95%	76,19%	C	Medium
Product 2099	76%	1	0,95%	77,14%	C	Medium
Product 2078	77%	1	0,95%	78,10%	C	Medium
Product 2102	78%	1	0,95%	79,05%	C	Medium
Product 2095	79%	1	0,95%	80,00%	C	Medium
Product 1540	80%	1	0,95%	80,95%	C	Medium
Product 1422	81%	1	0,95%	81,90%	C	Medium
Product 1412	82%	1	0,95%	82,86%	C	Medium
Product 2096	83%	1	0,95%	83,81%	C	Medium
Product 1743	84%	1	0,95%	84,76%	C	Medium
Product 2027	85%	1	0,95%	85,71%	C	Medium
Product 2106	86%	1	0,95%	86,67%	C	Medium
Product 1799	87%	1	0,95%	87,62%	C	Medium
Product 2081	88%	1	0,95%	88,57%	C	Medium
Product 2100	89%	1	0,95%	89,52%	C	Medium
Product 2052	90%	1	0,95%	90,48%	C	Medium
Product 2101	91%	1	0,95%	91,43%	C	Medium

Product 2114	92%	1	0,95%	92,38%	C	Medium
Product 2049	93%	1	0,95%	93,33%	C	Medium
Product 1945	94%	1	0,95%	94,29%	C	Medium
Product 2112	95%	1	0,95%	95,24%	C	Medium
Product 2113	96%	1	0,95%	96,19%	C	Medium
Product 2115	97%	1	0,95%	97,14%	C	Medium
Product 2060	98%	1	0,95%	98,10%	C	Medium
Product 2050	99%	1	0,95%	99,05%	C	Medium
Product 2066	100%	1	0,95%	100,00%	C	Medium

Appendix BB – Class-Based Reallocation: PFBE Family

SKU	Volume		New Location
	Cm^3	Cumulative	
Product 672	1 552,63	1 552,63	PFBE-Z5
Product 270	2 323,94	3 876,57	PFBE-Z5
Product 1515	4 211,36	8 087,93	PFBE-Z5
Product 192	1 449,51	9 537,44	PFBE-Z5
Product 1768	8 422,72	17 960,16	PFBE-Z5
Product 1710	7 018,93	24 979,09	PFBE-Z5
Product 818	1 055,81	26 034,89	PFBE-Z5
Product 813	756,00	26 790,89	PFBE-Z5
Product 207	1 577,09	28 367,98	PFBE-Z5
Product 202	1 536,48	29 904,46	PFBE-Z5
Product 697	2 163,20	32 067,66	PFBE-Z5
Product 708	1 374,45	33 442,11	PFBE-Z5
Product 591	19 519,75	52 961,86	PFBE-Z5
Product 741	2 250,00	55 211,86	PFBE-Z5
Product 417	5 929,20	61 141,06	PFBE-Z5
Product 134	990,00	62 131,06	PFBE-Z5
Product 1474	476,00	62 607,06	PFBE-Z5
Product 673	887,33	63 494,38	PFBE-Z5
Product 676	887,33	64 381,71	PFBE-Z5
Product 699	425,81	64 807,52	PFBE-Z5
Product 707	2 430,33	67 237,85	PFBE-Z5
Product 731	1 336,32	68 574,17	PFBE-Z5
Product 732	2 613,60	71 187,77	PFBE-Z5
Product 567	15 960,00	87 147,77	PFBE-Z5
Product 775	3 830,40	90 978,17	PFBE-Z5
Product 777	593,19	91 571,36	PFBE-Z5
Product 1763	8 422,72	99 994,08	PFBE-Z5
Product 799	412,37	100 406,45	PFBE-Z5
Product 806	4 054,85	104 461,29	PFBE-Z5
Product 419	6 001,28	110 462,57	PFBE-Z5
Product 388	5 049,00	115 511,57	PFBE-Z5
Product 858	6 137,00	121 648,57	PFBE-Z5
Product 2376	435,42	122 083,99	PFBE-Z5
Product 788	87,41	122 171,40	PFBE-Z5
Product 698	801,69	122 973,09	PFBE-Z5
Product 669	5 458,32	128 431,41	PFBE-Z5
Product 679	12 310,85	140 742,26	PFBE-Z5
Product 655	51 800,00	192 542,26	PFBE-Z5
Product 653	49 896,00	242 438,26	PFBE-Z5

Product 648	42 034,61	284 472,87	PFBE-Z5
Product 640	36 710,31	321 183,18	PFBE-Z5
Product 2025	25 268,15	346 451,32	PFBE-Z5
Product 721	202,27	346 653,60	PFBE-Z5
Product 723	4 469,41	351 123,00	PFBE-Z5
Product 727	2 601,06	353 724,07	PFBE-Z5
Product 736	384,25	354 108,32	PFBE-Z5
Product 557	15 051,43	369 159,75	PFBE-Z5
Product 737	872,13	370 031,88	PFBE-Z5
Product 1891	12 634,07	382 665,95	PFBE-Z5
Product 746	1 089,00	383 754,96	PFBE-Z5
Product 753	193,28	383 948,24	PFBE-Z5
Product 758	632,40	384 580,64	PFBE-Z5
Product 510	10 328,01	394 908,65	PFBE-Z5
Product 771	58,97	394 967,62	PFBE-Z5
Product 781	1 502,24	396 469,85	PFBE-Z5
Product 1773	8 422,72	404 892,57	PFBE-Z5
Product 493	8 963,36	413 855,93	PFBE-Z5
Product 482	8 401,59	422 257,52	PFBE-Z5
Product 473	7 989,05	430 246,57	PFBE-Z5
Product 791	195,10	430 441,67	PFBE-Z5
Product 792	3 418,76	433 860,43	PFBE-Z5
Product 458	7 481,04	441 341,47	PFBE-Z5
Product 797	912,00	442 253,47	PFBE-Z5
Product 384	4 987,90	447 241,37	PFBE-Z5
Product 825	626,12	447 867,48	PFBE-Z5
Product 822	221,83	448 089,31	PFBE-Z5
Product 815	7 345,73	455 435,04	PFBE-Z5
Product 1389	2 807,57	458 242,61	PFBE-Z5
Product 245	2 012,30	460 254,92	PFBE-Z5
Product 214	1 674,00	461 928,92	PFBE-Z5
Product 212	1 667,95	463 596,87	PFBE-Z5
Product 867	4 546,08	468 142,95	PFBE-Z5
Product 112	792,70	468 935,65	PFBE-Z5
Product 81	541,69	469 477,34	PFBE-Z5
Product 65	437,50	469 914,84	PFBE-Z5
Product 35	102,83	470 017,67	PFBE-Z5
Product 1964	10 109,47	480 127,14	PFBE-Z5
Product 1948	7 674,25	487 801,39	PFBE-Z5
Product 1947	7 246,50	495 047,89	PFBE-Z5
Product 2018	202,27	495 250,16	PFBE-Z5
Product 1824	2 556,00	497 806,16	PFBE-Z5
Product 1692	1 261,26	499 067,42	PFBE-Z5
Product 892	740,43	499 807,84	PFBE-Z5
Product 1576	651,24	500 459,08	PFBE-Z5

Product 1543	551,15	501 010,24	PFBE-Z5
Product 1489	520,00	501 530,24	PFBE-Z5
Product 739	577,50	577,50	PFBE-Z4
Product 665	75 620,99	76 198,49	PFBE-Z4
Product 700	2 800,25	78 998,74	PFBE-Z4
Product 705	1 131,90	80 130,64	PFBE-Z4
Product 2031	28 075,72	108 206,35	PFBE-Z4
Product 710	15 592,50	123 798,85	PFBE-Z4
Product 627	30 786,17	154 585,02	PFBE-Z4
Product 711	3 960,00	158 545,02	PFBE-Z4
Product 712	596,65	159 141,67	PFBE-Z4
Product 713	3 164,11	162 305,77	PFBE-Z4
Product 624	27 750,91	190 056,69	PFBE-Z4
Product 623	27 455,00	217 511,69	PFBE-Z4
Product 717	14 745,60	232 257,29	PFBE-Z4
Product 720	142,20	232 399,49	PFBE-Z4
Product 2001	21 056,79	253 456,27	PFBE-Z4
Product 722	283,90	253 740,18	PFBE-Z4
Product 724	1 968,12	255 708,30	PFBE-Z4
Product 600	21 126,62	276 834,92	PFBE-Z4
Product 559	15 210,00	292 044,92	PFBE-Z4
Product 743	20,31	292 065,23	PFBE-Z4
Product 744	5 042,27	297 107,50	PFBE-Z4
Product 1857	11 230,29	308 337,78	PFBE-Z4
Product 1853	11 230,29	319 568,07	PFBE-Z4
Product 749	51,35	319 619,42	PFBE-Z4
Product 748	11,62	319 631,04	PFBE-Z4
Product 750	70,62	319 701,66	PFBE-Z4
Product 751	11 594,52	331 296,18	PFBE-Z4
Product 1860	11 230,29	342 526,47	PFBE-Z4
Product 1855	11 230,29	353 756,75	PFBE-Z4
Product 763	284,13	354 040,88	PFBE-Z4
Product 765	2 705,70	356 746,58	PFBE-Z4
Product 520	10 899,21	367 645,79	PFBE-Z4
Product 501	9 779,48	377 425,27	PFBE-Z4
Product 778	251,00	377 676,27	PFBE-Z4
Product 770	748,73	378 425,00	PFBE-Z4
Product 772	3 239,11	381 664,11	PFBE-Z4
Product 774	3 239,11	384 903,22	PFBE-Z4
Product 769	11 337,30	396 240,52	PFBE-Z4
Product 1767	8 422,72	404 663,24	PFBE-Z4
Product 490	8 802,30	413 465,54	PFBE-Z4
Product 790	469,20	413 934,74	PFBE-Z4
Product 1709	7 018,93	420 953,67	PFBE-Z4
Product 1719	7 018,93	427 972,60	PFBE-Z4

Product 456	7 343,73	435 316,33	PFBE-Z4
Product 439	6 583,50	441 899,83	PFBE-Z4
Product 435	6 522,12	448 421,95	PFBE-Z4
Product 1646	5 615,14	454 037,09	PFBE-Z4
Product 802	558,14	454 595,22	PFBE-Z4
Product 805	567,18	455 162,40	PFBE-Z4
Product 1622	5 615,14	460 777,55	PFBE-Z4
Product 426	6 269,40	467 046,95	PFBE-Z4
Product 416	5 921,16	472 968,11	PFBE-Z4
Product 403	5 423,55	478 391,66	PFBE-Z4
Product 381	4 774,37	483 166,02	PFBE-Z4
Product 821	39,60	483 205,62	PFBE-Z4
Product 820	56,07	483 261,69	PFBE-Z4
Product 823	1 484,80	484 746,49	PFBE-Z4
Product 824	3 056,13	487 802,62	PFBE-Z4
Product 345	3 769,21	491 571,83	PFBE-Z4
Product 340	3 605,38	495 177,21	PFBE-Z4
Product 335	3 533,40	498 710,61	PFBE-Z4
Product 332	3 399,53	502 110,14	PFBE-Z4
Product 847	531,02	502 641,16	PFBE-Z4
Product 838	147,71	502 788,88	PFBE-Z4
Product 831	1 248,30	504 037,18	PFBE-Z4
Product 840	6 997,26	6 997,26	PFBE-O2
Product 839	11 594,52	18 591,78	PFBE-O2
Product 1382	2 807,57	21 399,35	PFBE-O2
Product 322	3 075,80	24 475,15	PFBE-O2
Product 318	2 997,96	27 473,11	PFBE-O2
Product 313	2 931,45	30 404,56	PFBE-O2
Product 284	2 533,39	32 937,95	PFBE-O2
Product 275	2 343,60	35 281,55	PFBE-O2
Product 265	2 276,44	37 557,99	PFBE-O2
Product 255	2 144,74	39 702,73	PFBE-O2
Product 252	2 125,11	41 827,85	PFBE-O2
Product 210	1 602,44	43 430,29	PFBE-O2
Product 859	14 653,32	58 083,61	PFBE-O2
Product 857	639,45	58 723,06	PFBE-O2
Product 853	429,29	59 152,34	PFBE-O2
Product 860	230,89	59 383,23	PFBE-O2
Product 863	453,96	59 837,19	PFBE-O2
Product 862	561,37	60 398,56	PFBE-O2
Product 196	1 489,71	61 888,27	PFBE-O2
Product 189	1 428,00	63 316,27	PFBE-O2
Product 169	1 264,49	64 580,77	PFBE-O2
Product 162	1 220,00	65 800,77	PFBE-O2
Product 156	1 169,83	66 970,60	PFBE-O2

Product 155	1 168,08	68 138,68	PFBE-O2
Product 110	777,00	68 915,68	PFBE-O2
Product 89	597,96	69 513,64	PFBE-O2
Product 73	499,97	70 013,61	PFBE-O2
Product 2045	1 275,96	71 289,57	PFBE-O2
Product 2107	1 236,27	72 525,84	PFBE-O2
Product 1992	19 296,11	91 821,95	PFBE-O2
Product 2010	495,22	92 317,17	PFBE-O2
Product 1977	13 271,33	105 588,49	PFBE-O2
Product 1972	11 467,50	117 055,99	PFBE-O2
Product 1966	10 388,77	127 444,76	PFBE-O2
Product 1944	7 130,97	134 575,73	PFBE-O2
Product 2019	49,50	134 625,24	PFBE-O2
Product 1872	4 068,24	138 693,48	PFBE-O2
Product 2028	11,42	138 704,89	PFBE-O2
Product 2029	1 290,30	139 995,19	PFBE-O2
Product 1866	3 961,75	143 956,94	PFBE-O2
Product 1836	2 938,80	146 895,74	PFBE-O2
Product 2054	65,52	146 961,26	PFBE-O2
Product 1250	1 851,06	148 812,33	PFBE-O2
Product 1739	1 442,81	150 255,13	PFBE-O2
Product 1734	1 369,50	151 624,63	PFBE-O2
Product 1694	1 272,96	152 897,59	PFBE-O2
Product 2108	932,88	153 830,47	PFBE-O2
Product 1664	1 020,60	154 851,07	PFBE-O2
Product 2121	688,90	155 539,97	PFBE-O2
Product 1581	681,45	156 221,42	PFBE-O2
Product 1560	607,46	156 828,88	PFBE-O2
Product 1544	559,65	157 388,53	PFBE-O2
Product 1494	533,61	157 922,14	PFBE-O2
Product 686	370,21	158 292,36	PFBE-O2
Product 695	370,21	158 662,57	PFBE-O2
Product 2316	355,68	159 018,25	PFBE-O2
Product 2258	165,00	159 183,25	PFBE-O2
Product 2133	1,35	159 184,60	PFBE-O2
Product 2132	1,13	159 185,72	PFBE-O2
Product 742	110,21	2 565 946,83	PFBE-V2
Product 783	219,91	2 564 394,21	PFBE-V2
Product 668	87 132,67	2 562 070,26	PFBE-V2
Product 674	670,57	2 557 858,90	PFBE-V2
Product 675	577,85	2 556 409,39	PFBE-V2
Product 677	670,57	2 547 986,68	PFBE-V2
Product 678	538,56	2 540 967,75	PFBE-V2
Product 680	5 142,17	2 539 911,94	PFBE-V2
Product 681	498,46	2 539 155,94	PFBE-V2

Product 682	163,68	2 537 578,85	PFBE-V2
Product 2068	40 709,79	2 536 042,37	PFBE-V2
Product 646	39 941,54	2 533 879,17	PFBE-V2
Product 701	9 491,04	2 532 504,72	PFBE-V2
Product 702	781,44	2 512 984,98	PFBE-V2
Product 704	120,12	2 510 734,98	PFBE-V2
Product 703	14 258,62	2 504 805,78	PFBE-V2
Product 706	2 610,00	2 503 815,78	PFBE-V2
Product 2038	30 883,29	2 503 339,78	PFBE-V2
Product 2040	30 883,29	2 502 452,45	PFBE-V2
Product 629	31 732,01	2 501 565,12	PFBE-V2
Product 2030	28 075,72	2 501 139,31	PFBE-V2
Product 709	152,37	2 498 708,98	PFBE-V2
Product 626	29 690,50	2 497 372,66	PFBE-V2
Product 715	167,96	2 494 759,06	PFBE-V2
Product 714	1 925,18	2 478 799,06	PFBE-V2
Product 716	383,67	2 474 968,66	PFBE-V2
Product 2017	23 864,36	2 474 375,47	PFBE-V2
Product 719	4 683,65	2 465 952,76	PFBE-V2
Product 718	2 246,14	2 465 540,39	PFBE-V2
Product 609	22 332,46	2 461 485,54	PFBE-V2
Product 607	22 242,22	2 455 484,26	PFBE-V2
Product 1985	19 653,00	2 450 435,26	PFBE-V2
Product 725	18 299,90	2 444 298,26	PFBE-V2
Product 726	26 968,03	2 443 862,84	PFBE-V2
Product 733	488,80	2 443 775,43	PFBE-V2
Product 587	18 900,30	2 501 506,37	PFBE-Z3
Product 586	18 519,73	2 496 048,05	PFBE-Z3
Product 581	18 057,60	2 483 737,21	PFBE-Z3
Product 580	18 057,60	2 431 937,21	PFBE-Z3
Product 577	17 616,90	2 382 041,21	PFBE-Z3
Product 734	2 547,66	2 340 006,60	PFBE-Z3
Product 735	437,19	2 303 296,29	PFBE-Z3
Product 573	16 870,22	2 278 028,14	PFBE-Z3
Product 566	15 853,66	2 277 825,87	PFBE-Z3
Product 555	14 331,17	2 273 356,46	PFBE-Z3
Product 1884	12 634,07	2 270 755,40	PFBE-Z3
Product 740	6 602,10	2 270 371,15	PFBE-Z3
Product 738	3 714,61	2 255 319,72	PFBE-Z3
Product 745	2 541,00	2 254 447,59	PFBE-Z3
Product 551	13 807,50	2 241 813,52	PFBE-Z3
Product 755	1 846,21	2 240 724,51	PFBE-Z3
Product 754	293,63	2 240 531,23	PFBE-Z3
Product 747	1 268,80	2 239 898,83	PFBE-Z3
Product 752	284,58	2 229 570,82	PFBE-Z3

Product 757	23 822,60	2 229 511,85	PFBE-Z3
Product 756	795,34	2 228 009,61	PFBE-Z3
Product 542	12 573,82	2 219 586,90	PFBE-Z3
Product 532	11 699,76	2 210 623,54	PFBE-Z3
Product 764	2 964,08	2 202 221,95	PFBE-Z3
Product 761	2 215,20	2 194 232,90	PFBE-Z3
Product 760	782,47	2 194 037,80	PFBE-Z3
Product 759	742,50	2 190 619,04	PFBE-Z3
Product 762	7 708,68	2 183 138,00	PFBE-Z3
Product 766	3 788,40	2 182 226,00	PFBE-Z3
Product 517	10 768,14	2 177 238,10	PFBE-Z3
Product 515	10 649,50	2 176 611,98	PFBE-Z3
Product 509	10 152,80	2 176 390,15	PFBE-Z3
Product 500	9 732,45	2 169 044,42	PFBE-Z3
Product 498	9 466,07	2 166 236,85	PFBE-Z3
Product 776	400,00	2 164 224,55	PFBE-Z3
Product 773	2 704,80	2 162 550,55	PFBE-Z3
Product 1769	8 422,72	2 160 882,60	PFBE-Z3
Product 1775	8 422,72	2 156 336,52	PFBE-Z3
Product 779	7 057,58	2 155 543,82	PFBE-Z3
Product 768	118,73	2 155 002,13	PFBE-Z3
Product 767	4 172,80	2 154 564,63	PFBE-Z3
Product 780	1 560,30	2 154 461,80	PFBE-Z3
Product 782	19 671,08	2 144 352,33	PFBE-Z3
Product 784	5 398,52	2 136 678,08	PFBE-Z3
Product 496	9 266,40	2 129 431,58	PFBE-Z3
Product 495	9 018,27	2 129 229,31	PFBE-Z3
Product 489	8 758,26	2 126 673,31	PFBE-Z3
Product 477	8 303,34	2 125 412,05	PFBE-Z3
Product 474	8 069,99	2 124 671,62	PFBE-Z3
Product 1731	7 018,93	2 124 020,38	PFBE-Z3
Product 785	671,11	2 123 469,23	PFBE-Z3
Product 1705	7 018,93	2 122 949,23	PFBE-Z3
Product 787	1 208,32	2 122 371,73	PFBE-Z3
Product 789	879,75	2 046 750,75	PFBE-Z3
Product 786	6 247,20	2 043 950,49	PFBE-Z3
Product 793	1 151,40	2 042 818,59	PFBE-Z3
Product 794	651,17	2 014 742,88	PFBE-Z3
Product 467	7 707,02	1 999 150,38	PFBE-Z3
Product 465	7 630,00	1 968 364,21	PFBE-Z3
Product 457	7 380,99	1 964 404,21	PFBE-Z3
Product 434	6 493,94	1 963 807,56	PFBE-Z3
Product 432	6 434,73	1 960 643,46	PFBE-Z3
Product 431	6 382,99	1 932 892,55	PFBE-Z3
Product 800	43,94	1 905 437,55	PFBE-Z3

Product 1645	5 615,14	1 890 691,95	PFBE-Z3
Product 1627	5 615,14	1 890 549,75	PFBE-Z3
Product 801	540,85	1 869 492,96	PFBE-Z3
Product 798	4 403,20	1 869 209,05	PFBE-Z3
Product 804	907,50	1 867 240,93	PFBE-Z3
Product 803	83,66	1 846 114,32	PFBE-Z3
Product 1617	5 615,14	1 830 904,32	PFBE-Z3
Product 807	857,72	1 830 884,00	PFBE-Z3
Product 808	1 168,16	1 825 841,74	PFBE-Z3
Product 809	647,36	1 814 611,45	PFBE-Z3
Product 1624	5 615,14	1 803 381,16	PFBE-Z3
Product 412	5 875,20	1 809 577,39	PFBE-O1
Product 390	5 087,76	1 809 565,78	PFBE-O1
Product 387	5 043,00	1 809 495,15	PFBE-O1
Product 382	4 892,94	1 797 900,63	PFBE-O1
Product 817	401,94	1 786 670,35	PFBE-O1
Product 1502	4 211,36	1 775 440,06	PFBE-O1
Product 816	36 699,26	1 775 155,93	PFBE-O1
Product 819	3 171,03	1 772 450,24	PFBE-O1
Product 814	4 384,54	1 761 551,03	PFBE-O1
Product 812	2 850,41	1 751 771,54	PFBE-O1
Product 828	219,30	1 751 520,54	PFBE-O1
Product 1516	4 211,36	1 750 771,82	PFBE-O1
Product 1498	4 211,36	1 747 532,70	PFBE-O1
Product 826	1 799,03	1 744 293,59	PFBE-O1
Product 827	29 369,57	1 732 956,29	PFBE-O1
Product 829	1 353,24	1 724 533,58	PFBE-O1
Product 373	4 649,84	1 715 731,28	PFBE-O1
Product 356	4 032,95	1 715 262,08	PFBE-O1
Product 338	3 575,61	1 708 243,15	PFBE-O1
Product 336	3 535,49	1 701 224,22	PFBE-O1
Product 324	3 152,70	1 693 880,49	PFBE-O1
Product 841	4 858,32	1 687 296,99	PFBE-O1
Product 849	4 527,04	1 680 774,87	PFBE-O1
Product 1377	2 807,57	1 675 159,73	PFBE-O1
Product 835	2 580,00	1 674 601,59	PFBE-O1
Product 832	1 250,83	1 674 034,41	PFBE-O1
Product 833	1 023,22	1 668 419,27	PFBE-O1
Product 836	640,58	1 662 149,87	PFBE-O1
Product 837	447,30	1 656 228,71	PFBE-O1
Product 1376	2 807,57	1 650 805,16	PFBE-O1
Product 842	2 522,63	1 646 030,79	PFBE-O1
Product 1391	2 807,57	1 645 991,19	PFBE-O1
Product 843	3 457,44	1 645 935,12	PFBE-O1
Product 848	1 516,16	1 644 450,32	PFBE-O1

Product 834	655,14	1 641 394,19	PFBE-O1
Product 845	2 386,80	1 637 624,98	PFBE-O1
Product 844	1 250,20	1 634 019,60	PFBE-O1
Product 1371	2 807,57	1 630 486,20	PFBE-O1
Product 846	1 386,00	1 627 086,68	PFBE-O1
Product 312	2 928,42	1 626 555,65	PFBE-O1
Product 310	2 923,83	1 626 407,94	PFBE-O1
Product 308	2 894,84	1 625 159,64	PFBE-O1
Product 266	2 299,00	1 618 162,38	PFBE-O1
Product 260	2 232,45	1 606 567,86	PFBE-O1
Product 257	2 193,71	1 603 760,29	PFBE-O1
Product 256	2 156,22	1 600 684,49	PFBE-O1
Product 253	2 128,39	1 597 686,53	PFBE-O1
Product 251	2 118,96	1 594 755,08	PFBE-O1
Product 248	2 106,99	1 592 221,69	PFBE-O1
Product 244	1 978,74	1 589 878,09	PFBE-O1
Product 230	1 805,80	1 587 601,65	PFBE-O1
Product 229	1 793,75	1 585 456,91	PFBE-O1
Product 209	1 601,60	1 583 331,79	PFBE-O1
Product 208	1 593,24	1 581 729,35	PFBE-O1
Product 871	1 297,30	1 567 076,03	PFBE-O1
Product 1108	1 403,79	1 566 436,58	PFBE-O1
Product 861	1 911,78	1 566 007,30	PFBE-O1
Product 856	1 102,08	1 565 776,41	PFBE-O1
Product 854	447,64	1 565 322,45	PFBE-O1
Product 865	2 579,36	1 564 761,08	PFBE-O1
Product 864	6 861,58	1 563 271,37	PFBE-O1
Product 851	3 539,91	1 561 843,37	PFBE-O1
Product 866	1 387,87	1 560 578,87	PFBE-O1
Product 1120	1 403,79	1 559 358,87	PFBE-O1
Product 852	945,35	1 558 189,04	PFBE-O1
Product 855	9 542,78	1 557 020,96	PFBE-O1
Product 868	964,78	1 556 243,96	PFBE-O1
Product 869	43,36	1 555 646,00	PFBE-O1
Product 870	17 211,64	1 555 146,03	PFBE-O1
Product 200	1 533,00	1 553 870,07	PFBE-O1
Product 197	1 512,00	1 552 633,80	PFBE-O1
Product 190	1 431,27	1 533 337,69	PFBE-O1
Product 165	1 240,27	1 532 842,47	PFBE-O1
Product 129	949,76	1 519 571,15	PFBE-O1
Product 128	934,96	1 508 103,65	PFBE-O1
Product 95	655,65	1 497 714,88	PFBE-O1
Product 94	650,00	1 490 583,91	PFBE-O1
Product 83	547,34	1 490 534,40	PFBE-O1
Product 374	4 693,00	1 486 466,16	PFBE-O1

Product 2011	22,26	1 486 454,75	PFBE-O1
Product 2022	2 715,75	1 485 164,45	PFBE-O1
Product 2036	218,68	1 481 202,70	PFBE-O1
Product 2044	973,73	1 478 263,90	PFBE-O1
Product 2067	5 156,20	1 478 198,38	PFBE-O1
Product 2069	2 091,12	1 476 347,31	PFBE-O1
Product 2118	913,50	1 474 904,51	PFBE-O1
Product 2127	369,38	1 473 535,01	PFBE-O1
Product 2128	369,38	1 472 262,05	PFBE-O1
Product 2126	98,02	1 471 329,17	PFBE-O1
Product 2005	18 350,00	1 470 308,57	PFBE-O1
Product 1998	1 210,88	1 469 619,67	PFBE-O1
Product 1995	23 504,32	1 468 938,22	PFBE-O1
Product 1980	14 691,60	1 468 330,76	PFBE-O1
Product 1978	13 606,80	1 467 771,11	PFBE-O1
Product 2012	2 032,80	1 467 237,50	PFBE-O1
Product 1976	12 803,62	1 466 867,28	PFBE-O1
Product 1970	11 242,14	1 466 497,07	PFBE-O1
Product 2014	1 318,90	1 466 141,39	PFBE-O1
Product 1943	7 096,08	1 465 976,39	PFBE-O1
Product 1926	6 407,33	1 465 975,04	PFBE-O1
Product 1925	6 304,24	1 465 973,92	PFBE-O1
Product 1924	6 259,20	1 465 863,71	PFBE-O1
Product 1920	5 961,47	1 465 643,80	PFBE-O1
Product 1918	5 809,92	1 378 511,12	PFBE-O1
Product 2023	67,74	1 377 840,56	PFBE-O1
Product 2026	388,08	1 377 262,71	PFBE-O1
Product 1873	4 101,30	1 376 592,14	PFBE-O1
Product 1867	3 980,42	1 376 053,58	PFBE-O1
Product 2037	4 691,74	1 370 911,41	PFBE-O1
Product 2046	26,72	1 370 412,95	PFBE-O1
Product 2047	198,75	1 370 249,27	PFBE-O1
Product 1825	2 559,88	1 329 539,48	PFBE-O1
Product 1299	2 221,28	1 289 597,94	PFBE-O1
Product 1249	1 851,06	1 280 106,90	PFBE-O1
Product 1789	1 821,60	1 279 325,46	PFBE-O1
Product 2072	410,11	1 279 205,34	PFBE-O1
Product 1174	1 480,85	1 264 946,72	PFBE-O1
Product 2074	281,24	1 262 336,72	PFBE-O1
Product 1753	1 589,76	1 231 453,43	PFBE-O1
Product 1745	1 483,56	1 200 570,15	PFBE-O1
Product 1740	1 449,00	1 168 838,14	PFBE-O1
Product 1733	1 361,70	1 140 762,42	PFBE-O1
Product 1702	1 346,40	1 140 610,06	PFBE-O1
Product 1001	1 110,64	1 110 919,56	PFBE-O1

Product 2109	688,94	1 110 751,60	PFBE-O1
Product 1004	1 110,64	1 108 826,42	PFBE-O1
Product 1671	1 077,96	1 108 442,75	PFBE-O1
Product 1615	869,40	1 084 578,39	PFBE-O1
Product 1611	852,60	1 079 894,75	PFBE-O1
Product 2119	113,40	1 077 648,61	PFBE-O1
Product 2120	222,46	1 055 316,15	PFBE-O1
Product 1602	794,38	1 033 073,93	PFBE-O1
Product 1574	641,25	1 013 420,92	PFBE-O1
Product 1562	613,20	995 121,02	PFBE-O1
Product 1550	577,58	968 152,99	PFBE-O1
Product 1487	518,40	967 664,19	PFBE-O1
Product 1486	515,59	948 763,89	PFBE-O1
Product 1476	480,24	930 244,16	PFBE-O1
Product 1461	439,43	912 186,56	PFBE-O1
Product 693	370,21	894 128,96	PFBE-O1
Product 694	370,21	876 512,07	PFBE-O1
Product 683	370,21	873 964,41	PFBE-O1
Product 1450	400,87	873 527,22	PFBE-O1
Product 1309	234,60	856 657,00	PFBE-O1
Product 1247	173,38	840 803,34	PFBE-O1
Product 1045	73,30	826 472,17	PFBE-O1
Product 1485	512,99	813 838,10	PFBE-O1
Product 2377	837,00	807 236,00	PFBE-O1
Product 2379	524,80	803 521,39	PFBE-O1
Product 2354	734,14	800 980,39	PFBE-O1
Product 2278	210,60	787 172,89	PFBE-O1

Appendix CC – Class-Based Reallocation: ESKU Family

SKU	Volume		New Location
	Cm^3	Cumulative	
Product 2380	1 477,85	1 477,85	ESKU-D
Product 2381	886,71	2 364,56	ESKU-D
Product 2382	886,71	3 251,27	ESKU-D
Product 2383	1 182,28	4 433,55	ESKU-D
Product 2384	886,71	5 320,26	ESKU-D
Product 2385	591,14	5 911,40	ESKU-D
Product 2386	10 936,09	16 847,49	ESKU-D
Product 2387	591,14	17 438,63	ESKU-D
Product 2388	1 182,28	18 620,91	ESKU-D
Product 3189	4 729,12	23 350,03	ESKU-D
Product 2389	886,71	24 236,74	ESKU-D
Product 2390	13 300,65	37 537,39	ESKU-D
Product 2391	12 413,94	49 951,33	ESKU-D
Product 2393	1 182,28	51 133,61	ESKU-D
Product 2392	1 182,28	52 315,89	ESKU-D
Product 2394	886,71	53 202,60	ESKU-D
Product 2395	886,71	54 089,31	ESKU-D
Product 2396	591,14	54 680,45	ESKU-D
Product 2397	1 182,28	55 862,73	ESKU-D
Product 2403	8 867,10	64 729,83	ESKU-D
Product 2400	1 477,85	66 207,68	ESKU-D
Product 2402	1 477,85	67 685,53	ESKU-D
Product 2399	886,71	68 572,24	ESKU-D
Product 2398	591,14	69 163,38	ESKU-D
Product 2401	1 182,28	70 345,66	ESKU-D
Product 2404	886,71	71 232,37	ESKU-D
Product 2405	591,14	71 823,51	ESKU-D
Product 3148	13 596,22	85 419,73	ESKU-D
Product 2414	16 551,92	101 971,65	ESKU-D
Product 2408	8 867,10	110 838,75	ESKU-D
Product 2406	8 571,53	119 410,28	ESKU-D
Product 2407	2 955,70	122 365,98	ESKU-D
Product 2415	2 955,70	125 321,68	ESKU-D
Product 2410	886,71	126 208,39	ESKU-D
Product 2409	591,14	126 799,53	ESKU-D
Product 2411	591,14	127 390,67	ESKU-D
Product 2412	1 182,28	128 572,95	ESKU-D
Product 2413	591,14	129 164,09	ESKU-D
Product 2416	1 182,28	130 346,37	ESKU-D

Product 2636	1 182,28	131 528,65	ESKU-D
Product 2417	591,14	132 119,79	ESKU-D
Product 2418	591,14	132 710,93	ESKU-D
Product 2419	1 182,28	133 893,21	ESKU-D
Product 2420	1 182,28	135 075,49	ESKU-D
Product 2421	1 182,28	136 257,77	ESKU-D
Product 2422	591,14	136 848,91	ESKU-D
Product 2423	886,71	137 735,62	ESKU-D
Product 2974	886,71	138 622,33	ESKU-D
Product 2434	14 187,36	152 809,69	ESKU-D
Product 2428	8 867,10	161 676,79	ESKU-D
Product 2426	4 433,55	166 110,34	ESKU-D
Product 2492	2 068,99	168 179,33	ESKU-D
Product 3143	1 773,42	169 952,75	ESKU-D
Product 2429	1 477,85	171 430,60	ESKU-D
Product 2430	1 477,85	172 908,45	ESKU-D
Product 2424	1 182,28	174 090,73	ESKU-D
Product 2433	1 182,28	175 273,01	ESKU-D
Product 3163	886,71	176 159,72	ESKU-D
Product 2437	886,71	177 046,43	ESKU-D
Product 2436	1 182,28	178 228,71	ESKU-D
Product 3135	591,14	178 819,85	ESKU-D
Product 2425	591,14	179 410,99	ESKU-D
Product 2427	591,14	180 002,13	ESKU-D
Product 2431	591,14	180 593,27	ESKU-D
Product 2432	886,71	181 479,98	ESKU-D
Product 2435	591,14	182 071,12	ESKU-D
Product 2884	886,71	182 957,83	ESKU-D
Product 2530	1 182,28	184 140,11	ESKU-D
Product 2438	1 182,28	185 322,39	ESKU-D
Product 2548	591,14	185 913,53	ESKU-D
Product 2439	1 182,28	187 095,81	ESKU-D
Product 2440	591,14	187 686,95	ESKU-D
Product 2441	1 182,28	188 869,23	ESKU-D
Product 2442	886,71	189 755,94	ESKU-D
Product 2443	886,71	190 642,65	ESKU-D
Product 2444	591,14	191 233,79	ESKU-D
Product 2445	1 182,28	192 416,07	ESKU-D
Product 3044	886,71	193 302,78	ESKU-D
Product 2857	1 182,28	194 485,06	ESKU-D
Product 2446	886,71	195 371,77	ESKU-D
Product 2573	1 182,28	196 554,05	ESKU-D
Product 3203	1 182,28	197 736,33	ESKU-D
Product 2447	591,14	198 327,47	ESKU-D
Product 2460	19 212,05	217 539,52	ESKU-D

Product 3204	6 798,11	224 337,63	ESKU-D
Product 2448	5 615,83	229 953,46	ESKU-D
Product 2464	4 433,55	234 387,01	ESKU-D
Product 2465	4 433,55	238 820,56	ESKU-D
Product 2452	2 955,70	241 776,26	ESKU-D
Product 2450	2 660,13	244 436,39	ESKU-D
Product 3178	1 773,42	246 209,81	ESKU-D
Product 2451	1 477,85	247 687,66	ESKU-D
Product 2459	1 182,28	248 869,94	ESKU-D
Product 2456	886,71	249 756,65	ESKU-D
Product 2458	886,71	250 643,36	ESKU-D
Product 2463	886,71	251 530,07	ESKU-D
Product 2471	591,14	252 121,21	ESKU-D
Product 2449	1 182,28	253 303,49	ESKU-D
Product 2454	886,71	254 190,20	ESKU-D
Product 2455	591,14	254 781,34	ESKU-D
Product 2466	591,14	255 372,48	ESKU-D
Product 2467	886,71	256 259,19	ESKU-D
Product 2468	591,14	256 850,33	ESKU-D
Product 2469	1 182,28	258 032,61	ESKU-D
Product 2470	591,14	258 623,75	ESKU-D
Product 2472	886,71	259 510,46	ESKU-D
Product 2473	591,14	260 101,60	ESKU-D
Product 2474	886,71	260 988,31	ESKU-D
Product 2475	886,71	261 875,02	ESKU-D
Product 2453	591,14	262 466,16	ESKU-D
Product 2457	1 182,28	263 648,44	ESKU-D
Product 2461	886,71	264 535,15	ESKU-D
Product 2462	1 182,28	265 717,43	ESKU-D
Product 2574	591,14	266 308,57	ESKU-D
Product 3181	886,71	267 195,28	ESKU-D
Product 3193	1 182,28	268 377,56	ESKU-D
Product 2483	3 546,84	271 924,40	ESKU-D
Product 2482	2 068,99	273 993,39	ESKU-D
Product 2975	886,71	274 880,10	ESKU-D
Product 2484	886,71	275 766,81	ESKU-D
Product 2476	591,14	276 357,95	ESKU-D
Product 2477	1 182,28	277 540,23	ESKU-D
Product 2478	886,71	278 426,94	ESKU-D
Product 2479	591,14	279 018,08	ESKU-D
Product 2480	591,14	279 609,22	ESKU-D
Product 2481	1 182,28	280 791,50	ESKU-D
Product 3136	1 182,28	281 973,78	ESKU-D
Product 2620	886,71	282 860,49	ESKU-D
Product 3137	591,14	283 451,63	ESKU-D

Product 3164	886,71	284 338,34	ESKU-D
Product 2776	591,14	284 929,48	ESKU-D
Product 2485	886,71	285 816,19	ESKU-D
Product 2486	591,14	286 407,33	ESKU-D
Product 2934	886,71	287 294,04	ESKU-D
Product 2487	886,71	288 180,75	ESKU-D
Product 2488	591,14	288 771,89	ESKU-D
Product 3199	886,71	289 658,60	ESKU-D

Appendix DD – Class-Based Reallocation: FAI Family

SKU	Volume		New Location
	Cm^3	Cumulative	
Product 106	735,13	735,13	FAI-E
Product 2125	249,28	984,41	FAI-E
Product 2111	107,91	1 092,32	FAI-E
Product 2075	802,815	1 895,14	FAI-E
Product 2056	51,2256	1 946,36	FAI-E
Product 850	2762,208	4 708,57	FAI-E
Product 589	19277	23 985,57	FAI-E
Product 795	8570,835	32 556,40	FAI-E
Product 796	8570,835	41 127,24	FAI-E
Product 572	16619,616	57 746,85	FAI-E
Product 810	686,205	58 433,06	FAI-E
Product 447	6949,488	65 382,55	FAI-E
Product 830	1317,888	66 700,44	FAI-E
Product 605	21619,71	88 320,15	FAI-E
Product 575	17213,5	105 533,65	FAI-E
Product 549	13252,59	118 786,24	FAI-E
Product 523	11033,75	129 819,99	FAI-E
Product 396	5290,74	135 110,73	FAI-E
Product 483	8414,948	143 525,67	FAI-E
Product 438	6567,236	150 092,91	FAI-E
Product 194	1470	151 562,91	FAI-E
Product 525	11114,63	162 677,54	FAI-E
Product 811	31500	194 177,54	FAI-E
Product 411	5860,665	200 038,20	FAI-E
Product 144	1078,735	201 116,94	FAI-E
Product 139	1040,06	202 157,00	FAI-E
Product 149	1142,4	203 299,40	FAI-E
Product 872	6151,572	209 450,97	FAI-E
Product 2130	333,935	209 784,91	FAI-E
Product 1226	148,68	209 933,59	FAI-E
Product 1810	2246,4	212 179,99	FAI-E
Product 1653	966,368	213 146,35	FAI-E
Product 2034	480,636	213 626,99	FAI-E
Product 2021	39244,8	252 871,79	FAI-E
Product 2015	6468,75	259 340,54	FAI-E
Product 2110	1822,491	261 163,03	FAI-E
Product 2124	176,64	261 339,67	FAI-E
Product 2035	184,14	261 523,81	FAI-E
Product 2051	116,064	261 639,88	FAI-E

Product 2033	226,98	261 866,86	FAI-E
Product 2117	934,65	262 801,51	FAI-E
Product 2116	4705,611	267 507,12	FAI-E
Product 1415	2887,014346	270 394,13	FAI-E
Product 2016	5628,40038	276 022,53	FAI-E
Product 2048	406,824	276 429,36	FAI-E
Product 2092	160,3008	276 589,66	FAI-E
Product 1784	1766,4	278 356,06	FAI-E
Product 2020	196,196	278 552,25	FAI-E
Product 2123	224	278 776,25	FAI-E
Product 2122	63	278 839,25	FAI-E
Product 2083	121,203	278 960,46	FAI-E
Product 2076	92,16	279 052,62	FAI-E
Product 2089	901,016	279 953,63	FAI-E
Product 2103	483,7248	280 437,36	FAI-E
Product 2098	250,56	280 687,92	FAI-E
Product 2065	727,329	281 415,24	FAI-E
Product 2082	252,192	281 667,44	FAI-E
Product 2055	24436,776	306 104,21	FAI-E
Product 2097	602,272	306 706,48	FAI-E
Product 2079	231,99	306 938,47	FAI-E
Product 1665	1024,098	307 962,57	FAI-E
Product 2091	1370,726	309 333,30	FAI-E
Product 2093	28,42173	309 361,72	FAI-E
Product 2088	69,2874	309 431,01	FAI-E
Product 2032	142,848	309 573,86	FAI-E
Product 2013	1470,144	311 044,00	FAI-E
Product 2006	1030,3488	312 074,35	FAI-E
Product 2090	1279,2	313 353,55	FAI-E
Product 2105	59,4	313 412,95	FAI-E
Product 2061	40	313 452,95	FAI-E
Product 2129	1275,96	314 728,91	FAI-E
Product 2077	97,92	314 826,83	FAI-E
Product 2104	163,35	314 990,18	FAI-E
Product 1808	2161,25	317 151,43	FAI-E
Product 1760	1662,5	318 813,93	FAI-E
Product 2099	494,592	319 308,52	FAI-E
Product 2078	72,42	319 380,94	FAI-E
Product 2102	880,7292	320 261,67	FAI-E
Product 2095	1305,566	321 567,24	FAI-E
Product 1540	537,225	322 104,46	FAI-E
Product 1422	340,676	322 445,14	FAI-E
Product 1412	323,4	322 768,54	FAI-E
Product 2096	151,776	322 920,31	FAI-E
Product 1743	1471,756	324 392,07	FAI-E

Product 2027	17,856	324 409,93	FAI-E
Product 2106	1254,016	325 663,94	FAI-E
Product 1799	1890,783	327 554,72	FAI-E
Product 2081	68,4112	327 623,14	FAI-E
Product 2100	321,64	327 944,78	FAI-E
Product 2052	208,12	328 152,90	FAI-E
Product 2101	911,028	329 063,92	FAI-E
Product 2114	314,364	329 378,29	FAI-E
Product 2049	521,64	329 899,93	FAI-E
Product 1945	7183,692	337 083,62	FAI-E
Product 2112	48468,224	385 551,84	FAI-E
Product 2113	6924,032	392 475,88	FAI-E
Product 2115	35,2	392 511,08	FAI-E
Product 2060	44,1	392 555,18	FAI-E
Product 2050	98,552	392 653,73	FAI-E
Product 2066	37,8	392 691,53	FAI-E