Multi-disciplinary project (CIE 4061-09)

Bogotá, Colombia

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Redesigning Makro Colombia's Supply Chain Infrastructure

From a traffic flow and communication flow perspective

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Note: Appendices are in a separate booklet

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List of abbreviations:

3PL	Third Party Logistics
AL	Allocation List
All	Allocation
BI	Business Intelligence
CDC	Cross-docking center
DF	Dry-food
KPI	Key Performance Indicator
NF	Non-food
NoD	Notice of Difference
PDA	Primary Dispatch Announcement
PO	Purchase Order
PoO	Proof of Order
RDF	Retail Demand Forecasting
Rep	Replenishment
RMS	Oracle Retail Merchandising System
SDA	Secondary Dispatch Announcement
SKU	Stock Keeping Units
WMS	Warehouse Management System
ALC	Administration Logistics and Control
PLC	Packing List CDC
PLS	Packing List Store
PRA	Preliminary (Re-) Allocation

1. Introduction

1.1 Background

Makro South America is a cash-and-carry wholesaler that sells high volumes of food and non-food products to professional small and medium-sized retailers, the hospitality industry and other institutional customers (SHV, 2017). Makro is currently operating in five different countries in South America: Brazil, Peru, Argentina, Venezuela and Colombia, of which the last one will be the focus of this research. In 2011 and 2012 Makro opened another 19 new stores bringing the total number of stores in South America to 161 (Makro, 2016). The company is operated by Steenkolen Handels Vereeniging Holdings (SHV Holdings), which was originated in 1896 in the Netherlands as a large coal trading company. Currently, SHV is a family-owned multinational that, upon the general decline of coal as the primary source of energy, has diversified into a large range of other business areas, amongst which the wholesale sector, oil, financial services and transport (SHV, 2017). Makro South America started operating in Colombia in 1995. Today, there are 17 Makro stores in Colombia divided over 12 cities and its Head Office (HO) is located in Bogotá. Efficiency and the benefitting client are two key aspects that are point of focus in the current strategy of Makro Colombia.

Currently, Makro Colombia faces several problems such as low service levels, high levels of inventories and low productivity in the process of receiving merchandise in stores. Besides that, given the positive macroeconomic conditions and growth in consumption in the cash-and-carry business, Makro has planned to expand its operations by opening three new stores in Colombia by the end of 2017. To efficiently deal with current problems and the planned expansion, Makro is working on a redesign of the supply chain, by means of implementing a Cross Docking Center (CDC) and new retail software, called Oracle.

The CDC will be used for the cross docking of dry-foods (DF) and non-foods (NF), and a third-party logistics (3PL) company will be contracted to operate this CDC. The implementation of a CDC should ensure more efficient and economical operations, because it enables consolidation of orders of different suppliers in a single vehicle. The new retail software will serve all information flows within the future supply chain process with the CDC included. The implementation of the CDC and the transition to Oracle are both part of the so called M40+ project, initiated by Makro South America. With M40+ Makro aims to improve the efficiency of its current supply chain process.

1.2 Research objectives

The focus of this research is on three crucial aspects regarding to the implementation of the CDC and the transition to a new retail management system.

The first one is to develop a complete interface of the new communication system for the future supply chain model with the CDC included. This interface is understood as a set of software programmes that exchange information instantaneously, receiving input messages and sending output messages. The interface should be able to connect the Makro interface with the external interfaces of the suppliers and with the Warehouse Management System (WMS) of the CDC. Therefore it is important to map all the information exchange between the different actors that is crucial for an efficient communication flow.

The second aspect of focus is to develop an implementation protocol for the new communication system, consisting of a testing protocol and a planning. It is of great importance to know which parts need to be tested, in what sequence and how much time it will take. Strict deadlines and wishes of all different departments should be taken into account when defining this test protocol.

The third aspect focuses on the effect of the CDC on the transportation flows between the suppliers and Makro and around the CDC. The number and destination of deliveries in the current situation will change with respect to the number and destination of deliveries in the future situation with a CDC between the suppliers and Makro. The infrastructure around the CDC, consisting of parking space and unloading docks, needs to be able to handle the expected increase in traffic.

Together, these three aspects should be analysed which will provide Makro with a framework for its software architecture as well as a plan for its interface testing and implementation. Furthermore, a clear outline should be given as to what physical conditions the CDC must satisfy in order to streamline traffic flows in Makro's supply chain as effectively as possible.

1.3 Research Questions

To be able to provide Makro Colombia with a sufficient advice as regards the three problems described in the previous paragraph, three research questions are defined.

RQ1: How should Makro design the future flow of information between relevant actors and their information systems upon the implementation of a cross-docking center?

RQ2: How should the implementation for the future flow of information be designed?

RQ3: How should the cross-docking center in Bogotá be structured in order to optimally accommodate for the new traffic flow around it?

1.4 Methodology

In order to provide Makro Colombia with advice regarding the problem statement and to be able to answer the research questions formulated in the previous paragraph, several theories and methodologies are used.

1.4.1 Research design

This research is divided into four different phases, which function as a roadmap during the research and provide a clear overview of the different knowledge that has to be gained and in which order this has to be done.

Phase 1: Mapping the current processes of placing orders and receiving products at the Makro stores, including the step by step flow of goods and information.

Phase 2: Mapping the optimal future processes of placing orders and receiving products at the Makro stores, including the step by step flow of information.

Phase 3: Identifying the consequences of the changing number and destination of deliveries for the infrastructure around stores and the new CDC.

Phase 4: Formulate advice on designing the future flow of information, develop the testing protocol for the implementation of Oracle for the newly developed CDC and define the physical requirements for the infrastructure of the CDC.

To accomplish Phase 1, 2 and 3, theories about semi-structured interviews, Swimlane, traffic flow and Queueing Theory are used.

1.4.2 Semi-structured interviews

In order to gain all available information about the current and future supply chain model, a lot of semi-structured interviews need to be conducted. All input, coming from different departments, will be used to map both the current and future supply chain processes at Makro. Semi-structured interviews are often used in qualitative researches where thorough understanding of the answers is required (Edwards et al., 2013). In contrast to structured interviews, semi-structured interviews are open, just like real conversations. The standardized questions, well prepared by the researcher in advance, only function as guidelines and guarantee that all important topics are covered. During the interview it is allowed to bring up new ideas as a result of what the interviewee says. This can help the researcher to tailor the questions to the interview context (Harrell et al., 2009).

1.4.3 Swimlane diagrams

A Swimlane, or Swimlane diagram, is a tool that visualizes a workflow or process, including a distinction between jobs and responsibilities of actors in sub-processes. These jobs and responsibilities, activities, are visualized as boxes, their order of execution given by the arrows connecting the boxes. The activities are grouped in swimlanes, which can be horizontal rows or vertical columns. Each swimlane represents a function category, which can be actors, departments, or customers/suppliers. Swimlane can be used to analyze, document or design a process in various fields (Wedgwood, 2006). In the case of Makro, Swimlane could visualize the different flows of goods and information, starting at an order placement and ending at the delivery of products. Swimlane could also be used to visualize the different actors handling the products, describing what activities the actor performs.

1.4.4 Traffic Flow and Queueing Theory

The total number of deliveries for the current delivery process and two future delivery process scenarios will be determined by analysing supplier delivery data. By analysing the results such as the difference in total deliveries or total deliveries per supplier per month, the positive or negative effects of a CDC can be visualised in actual numbers. These numbers will als serve as input for the analysis using the queueing theory, in which the behavior of waiting lines for trucks at Makro stores and the CDC can be analyzed and evaluated with resulting values for expected waiting time, queue lengths and server utilization (Hillier, Lieberman, 2004). The key input components for analyzing queues are the arrival rate (λ), the service time (1/μ) and the number of servers in the system (s). The behavior of these key input processes are indicated in the Kendall notation A/B/C, where A depicts the arrival process, B depicts the service process and C depicts the number of servers. The notation for arrival and service processes can take on different forms, such as M for an exponential service distribution, or a D for a deterministic arrival process. The C can take on a few values, such as 1, when the system has 1 server, or s, when the system has multiple servers. Thus, the combination of different characters and values describes the behavior of a queue. The theory will be applied to determine the required parking space and number of servers at the CDC and Makro stores.

1.4.5 Report Structure

This report consists six different chapters. In chapter two the current situation at Makro is described, including all stakeholders, actors and processes. In chapter three the M40+ project is explained, which contains Makro's vision on improvement of the current supply chain process. Among other things, it will explain all the decisions that are already made by Makro Colombia regarding this large project. In chapter four the analysis of the communication and logistical infrastructure is shown. Therefore, the entire future supply chain process as proposed according to this research will be described. In chapter 5 the testing protocol for the new communication system is explained. This testing protocol will serve as input for an advice concerning the planning of the M40+ project until the CDC goes live. The report is closed with some clear recommendations in response to the analysis performed during this research.

2. Makro Current Situation

Makro Colombia is being driven from the Makro Head Office (HO) located in Bogotá. The Chief Executive Officer (CEO) of the company is Andries Govaert who is leading a team of about 200 employees at the HO. The HO consists of six main departments: Finance, Commercial, Human Resources, Supply Chain, Logistics and M40+. Makro Colombia has 17 stores of which most are in the main cities. Four stores are located in the Bogotá area, two stores in Cali, two stores in Medellin, five stores in cities along the north coast area, and four stores located in smaller cities throughout the country. Replenishment of the stores' stocks is done by about 800 suppliers, who deliver goods in the categories of Dry-Foods, Fresh-Foods and Non-Foods. The stores are all managed by a team of two store managers and additionally count about 100 employees, which are dedicated to work hard and are willing to travel far and work long hours.

In 2016 the market strategy was established for the period of 2016-2018. In this strategy six important unique selling points (USP), composed from the client's perspective, were presented that distinguish Makro Colombia from its competitors. All six USP's fit Makro's general mission, which is stated by the SHV website as: "distribute products with excellence in price, quality and variety to professional customers, offering them competitive advantages and opportunities for growth".

- All products are to be found under one roof
- Solutions regarding the assortment are provided
- Money is saved
- A quick shopping experience is provided
- Professional care is provided
- Support is offered in developing a client's company

The rest of the market strategy is based on these USP's and will be explained in more detail in chapter 3.

The current situation, as described in this chapter, is defined as the situation as witnesses at the start of this project, including some transitions already implemented compared to the earlier situation. In paragraph 2.1, the entire supply chain process in the current situation is described. This process is divided into three different phases, which are further explained in 2.1.1 until 2.1.3. In paragraph 2.2, the analysis of the current delivery process is described and concluded with a queueing analysis at one of the bigger Makro stores.

2.1 Current Supply Chain Process

In figure 1 an overview of the current supply chain process of Makro Colombia is shown. For this report the current state is defined as the supply chain situation at start of the project. It is important to mention that by that time some trials had already been started that are not directly taken into account in the overview of this current state.

The main stakeholders within the Makro supply chain are the stores, the HO and the suppliers. These stakeholders are connected through different information flows (dashed line) and physical flows (solid line). The exchange of information between the stakeholders currently happens through the Makro Business System (MBS). This communication system was introduced at Makro South America about 40 years ago and it has become more and more outdated and complicated over the years because of system modifications. These MBS modifications differ per country, so not all systems within Makro South America are completely comparable. MBS is currently used for all communication throughout the entire supply chain.

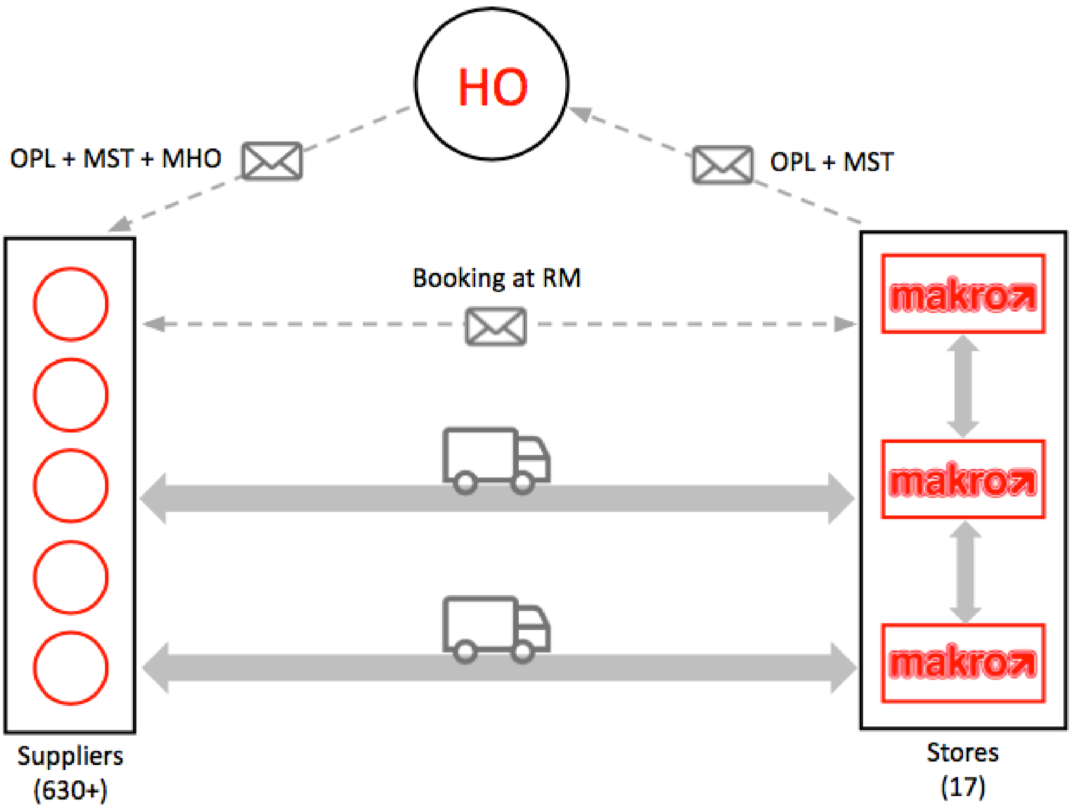

Figure 2.1: Current supply chain process for dry-food and non-food

In the context of this report, the current Makro supply chain as shown in figure 1, is divided into three different phases:

Phase 1: Quantification of needs
During the first phase the needs of all goods are quantified. Both the stores and the HO are involved in this process. The quantification is currently happening through the information flows referred to as OPL, MST and MHO. This process and these terms are further explained in paragraph 1.2.1.

Phase 2: Order placement
During the second phase orders are placed by the HO at the suppliers, using electronic communication platforms EDI and B2B. As shown in figure 1, currently there exists no order

confirmation coming from the suppliers. The entire process of order placement and the terms mentioned above are further explained in paragraph 1.2.2.

Phase 3: Distribution of merchandise

During the third phase goods are distributed directly from the suppliers to the stores. Some suppliers visit several stores during one ride to deliver their goods and some suppliers take refused or remaining goods back. The first aspect of the distribution phase is the booking, which is the communication about the delivery time and moment, initiated by either the supplier or the Makro store. The second aspect of this phase is the receipt of goods at the store from the supplier at the time that the supplier and the store agreed on, however in practice this is hardly the case. This phase is further explained in paragraph 1.2.3.

2.1.1 Quantification of Needs

In Phase 1, Quantification of Needs, the number of required products are estimated for every store in order to keep sufficient stocks to meet the demand. This process starts with the Night Run, a daily automatic routine executed at midnight, which updates stock information and ordering status in all systems at stores and at HO. The following quantification process consists of three steps, respectively OPL, MST, which take place at the individual Makro stores, and MHO, which takes place at the HO of Makro. Below, processes of OPL, MST and MHO are described.

OPL - Order Proposed List:	An algorithm in MBS, which gives a suggestion for the number of products to be ordered based on parameters such as the current stocks and sales records of the past few days. OPL is said to be an old and outdated algorithm, which creates faulty predictions, partly because only sales records of the past few days are considered. For this reason, in MST and MHO the orders are improved.
MST - Manual Store:	An option for the store manager of a Makro store to make amendments to the number of products suggested by OPL. Amendments are made on the basis of experience, such as the experience that more food is sold during a holiday.
MHO - Manual Head Office:	An option for the commercial department of HO to make amendments to the number of products suggested by OPL. Amendments are made on the basis of promotions in all stores and negotiations with suppliers.

The importance of the above described process of quantifying needs is underlined by two important KPI’s of Makro stores, namely the Service Level and the Stock Days. When the needs are estimated too low, products will run out of stock and customers are not able to buy these products. Service Level gives the percentage of times products were ‘on stock’, meaning a high Service Level is required. When the needs are estimated too high, products will stay in stock too long before they are sold, measured in Stock Days. High Stock Days lead to higher costs and are required to stay low.

In addition to the above mentioned process of quantifying needs, less frequent occurring situations require other ways of quantifying needs. These order processes are Return Orders, Transfer Orders and Extra Orders. Return Orders occur when articles are damaged or not delivered, in which case a negative order quantity is communicated with supplier and HO. A Transfer Order is when products are transferred between stores, in which one store ‘orders’ products at the other store. Lastly, the Extra Orders are generated for the receipt of free products, for instance for promotion purposes.

2.1.2 Order Placement

In Phase 2, Order Placement, the required products estimated in Phase 1, the sum of OPL, MST and MHO, are ordered at suppliers in a Purchase Order (PO). For placing PO’s at suppliers, two different electronic platforms for communication with suppliers are used, who both have different sequences of operation for Makro. The two communication platforms and the sequences are described below.

EDI - Electronic Data Interchange: *350 suppliers*	An electronic, automated platform providing a standard communication method between multiple actors. Every day in the Night Run, the PO’s are automatically sent to suppliers through the EDI. The EDI of the supplier will automatically send a receipt of the order.
B2B - Business to Business: *450 suppliers*	An electronic communication platform, working as an bulletin board on which Makro can place orders for one supplier. The supplier can fulfill the order, but a confirmation to Makro is not automatic and often absent. Through B2B, these orders are manually placed at suppliers in the afternoon when OPL, MST and MHO have produced PO’s. At midnight, the Night Run will process these orders in MBS.

Besides the above described electronic communication platforms, a few orders are still placed at suppliers by phone or E-mail. This might happen because the supplier works in this manner, or because it concerns an emergency order.

2.1.3 Distribution of Merchandise

In phase 3, Distribution of Merchandise, suppliers will accept the orders placed by Makro and distribute these to the stores. However, most suppliers do not inform Makro when they accept the order, until a booking is being made. The booking at the Makro store might come a few days after the supplier has accepted the order, leaving the Makro store unaware of the status of their order in the meantime. This is problematic, since often suppliers deliver less products, or stock keeping units (SKU’s), than were ordered. If the Makro store knows less SKU’s will be delivered, they can act on this by for instance ordering extra products at a different supplier. In new developments, 50 of the 350 EDI suppliers send an Dispatch Advice, which is a confirmation of accepting the order and containing information on the quantity of SKU's that will be delivered. The Dispatch Advice is automatically generated and send through EDI, keeping stores up to date on their orders.

After the orders are accepted and a booking has been made, the second part of the Distribution of Merchandise is the actual receipt of merchandise at the stores. As can be seen in the Swimlane diagram in Appendix C, when the supplier arrives at the Makro store at the agreed time, the first check is comparing the invoices brought by the supplier with the placed PO. The invoices are scanned using a program called DataCap, in which the scan is checked on legibility and is send to the Finance Department at HO. If the invoice does not match the original PO, corrections will be applied in DataCap, for Finance records, and in MBS, for store records. Following, the supplier will proceed to the unloading dock, where the truck is unloaded and where is checked if products are not broken and expiration date is reasonable for the type of product. The products that meet the criteria are scanned per SKU and recorded into MBS, after which Makro barcodes will be applied to the SKU's and the pallet with products will be sealed for warehouse safety. The products that did not meet the criteria will not be accepted and changes will again be applied into DataCap and a report will be made in MBS. A Notice of Difference will be created, stating the actual list of accepted products, which will also be signed by the supplier. A copy of the Notice of Difference is given to the supplier and another copy is sent to the Finance Department, after which the receipt of merchandise is completed.

A major problem in the current process of distribution is, as formulated by Store Manager Carlos Castañeda: ''In Colombia, the suppliers are king''. In daily routine, this results in suppliers not delivering the promised goods, showing up late, or even not showing up at all. Makro Store Managers have to make the best of these situations, which form a major bottleneck in the supply chain, adding to the priorly mentioned problems such as lowered service levels.

2.2 Traffic Flow: Current Delivery and Queueing Analysis

The quality of infrastructure enables and disables economic development, and to that regard Colombia does is lagging behind in the region as there is much room for improvement (Karpowicz, Matheson, Vtyurina, 2016). With no railway system and the Andes mountain ranges, transportation is only possible by busses and wheeled vehicles. On the Global Competitiveness Index, Colombia's infrastructure scores only 3.7 out of 7, making it one of the most problematic factors for doing business (Schwab, 2015). For businesses such as Makro, the state of the infrastructure in a country is an important factor as many trucks with Makro products need to cross this large and mountainous country. With 17 stores in Colombia, over 800 suppliers and not a single distribution center, there are many difficulties. Most importantly, there is a high density of trucks and there is quite a high chance that a supplier fails to deliver. Moreover, there is an increased likelihood of error when ordering, higher costs due to inefficiencies and there are many problems regarding entry and exit of the stores. In figure 2.2, the concept of a decentralized delivery provider is shown. Makro Colombia has used this concept for 20 years and will continue to do so until a distribution center is operational.

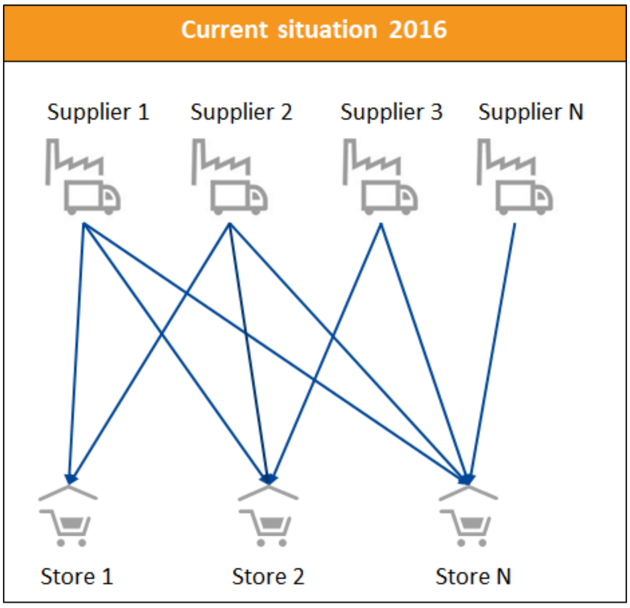

Figure 2.2: Concept of current situation: decentralized delivery provider

The difficulties, coming from the fact that there is no distribution center involved, in combination with Colombia's problematic infrastructure, makes logistics one of the main topics of concern for Makro and queuing of supplier trucks at stores is likely to occur. There are many improvements possible regarding these topics. In this section, the current flow of trucks driving from the suppliers to Makro and the queuing at stores that develop as a result of many simultaneous deliveries are analyzed.

In paragraph 2.2.1, the method of data gathering and data processing is described. Furthermore, the results of the delivery analysis are shown in paragraph 2.2.2. Lastly, the analysis of supplier trucks queuing at Makro stores in the current situation is discussed in paragraph 2.2.3.

2.2.1 Data gathering and data processing

The current system Makro uses to manage over 800 supplier in Colombia, was not as organized as was expected. It was hard to collect all the data from several departments such as Supply Chain, Commercial and Finance. December is the busiest month of the year for Makro. Seeing as the transport process needs to function in its peak times, the data used for this analysis of all deliveries regarding non-food and dry-food, is from december 2016.

The gathered data was in extensive .csv and .xls files, and as such was compiled in large Excel files. The raw data, collected from different departments in headquarters of Makro Colombia, contained a lot of chaotic data. The data relevant for the analysis of the current incoming deliveries was structured containing a list of suppliers (locations, names, volumes transported), a list of stores (locations, names, size) and the number of deliveries per month per supplier. With this data, it was possible analyse the deliveries of the current situation. Furthermore Excel was used to process relevant data in order to form a solid and thorough analysis of the traffic flows. Data processing is further elucidated in 'Analysis of all incoming NF and DF deliveries', see Appendix H.

2.2.2 Results delivery analysis of current situation

After processing the data in Excel, it was possible to produce results about the delivery analysis. Figure 2.3 shows the main results of the delivery analysis of the current situation. The total amount of deliveries for all stores is 13.341 per month. There are 17 Makro stores in Colombia which means that an average store receives 785 deliveries per month for DF and NF. This preliminary result gives a clear impression of the sheer size of Makro's supply chain structure and is a reminder of the colossal envisioned transition.

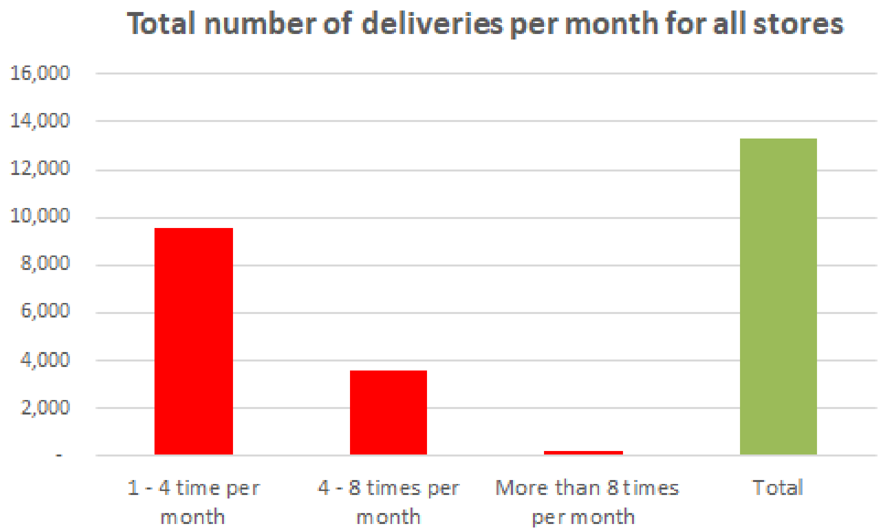

Figure 2.3: Total number of deliveries per month for all stores per frequency category

As described in paragraph 2.1, every delivery takes a lot of time to process. The driver needs to be registered, the receipt of merchandise must be confirmed and all the products in the trucks need to be checked on quantity and quality. This complex process in combination with too many deliveries per month, increases the likelihood of error tremendously. Figure 2.4 displays the average drop size per provider to all stores. It came to light that the average truck carries only 5 cubic meters of products. In comparison, a large truck often used in Colombia, the Mula, can transport 67 cubic meters. This means that a lot of trucks are delivering small amounts of products which creates a high density of trucks.

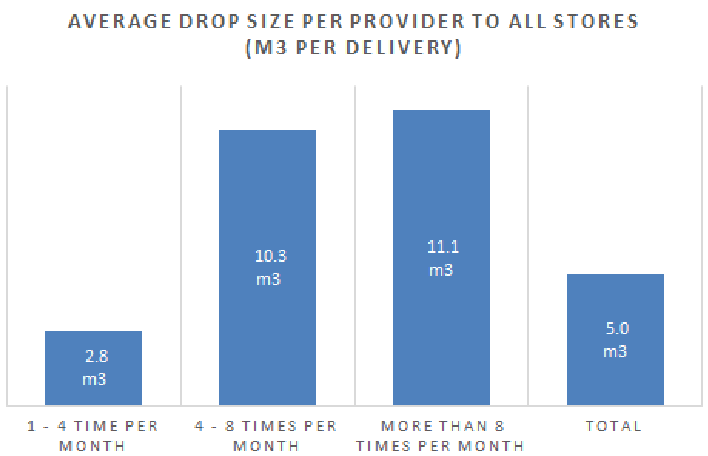

Figure 2.4: Average drop size per provider to all stores per frequency category

2.2.3 Queueing at stores

The large number of trucks entering and exiting the loading dock area in combination with the number of available unloading docks ensures that queuing at stores, especially during peak hours, is inevitable. Even more so, long queues at stores are a common situation and form a barrier for an efficient supply chain. Using the analyzed data described above, a queueing analysis has been performed on an example Makro store, in order to define what number of unloading docks is required to prevent long queues and long waiting times. The example store is Makro Cumará, located next to the Makro HO in Bogotá.

In the case of Makro stores handling supplier trucks at unloading docks, we consider an M/M/s queue. This queue is characterized by having a Poisson random arrival process, an exponentially distributed service time, and multiple servers. Furthermore, the queue is handled on the basis of 'first in first out', which states that the truck that has been in line longest, is served first. Also, it is assumed that actions of balking, when one refuses to join a waiting line, and reneging, when one leaves a waiting line, do not occur. Due to the fact that multiple servers have only one waiting line, jockeying, when one changes to a shorter waiting line, is not in question.

In order to analyze the queueing at Makro stores, several performance indicators are chosen and calculated using available data on the arrival rate (λ), the service time(1/μ) and the number of servers in the system (s). First of all, the server utilization (ρ), Equation 2.1, is calculated. Using the server utilization, the probability of waiting (C(s, λ/μ)), Equation 2.2, and subsequently the expected waiting time in queue (Wq), Equation 2.3, and the expected number of trucks in queue (Lq), Equation 2.4, can be calculated. Lastly, the service level (W(t)), Equation 2.5, can be calculated for several values of t.

$$\rho = \frac{\lambda}{s.\mu}$$

Equation 2.1: Server utilization

$$C\left(s, \frac{\lambda}{\mu}\right) = \frac{\frac{\left(\frac{\lambda}{\mu}\right)^s}{s!}}{\frac{\left(\frac{\lambda}{\mu}\right)^s}{s!} + (1-\rho)\sum_{n=0}^{s-1}\frac{\left(\frac{\lambda}{\mu}\right)^n}{n!}}$$

Equation 2.2: Probability of waiting

$$W_q = \frac{\frac{C(s,\frac{\lambda}{\mu})}{\mu}}{s(1-\frac{\lambda}{s.\mu})}$$

Equation 2.3: Expected waiting time in queue

$$L_q = W_q.\lambda$$

Equation 2.4: Expected number of trucks in queue

$$W(t) = 1 - C\left(s,\frac{\lambda}{\mu}\right).e^{(-(s-\lambda.t))}$$

Equation 2.5: Service level

In the case of Equation 2.5, the service level, the value for t, time, can be varied. In this research the chosen time unit is 1 hour, meaning that for instance for t = 0,5, a period of 30 minutes is considered. When this value would be chosen, the equation calculates the percentage of customers, supplier trucks, who wait in the queue less than 30 minutes.

To analyze the queueing at stores in general, the delivery process at an example store, Makro Cumará, is analyzed. Makro Cumará is one of the biggest Makro stores and receives 11,5% of the total amount of products delivered to all Makro stores, which amounts to 43 of the 494 total daily deliveries. Suppliers deliver goods at Cumará between 08:00 and 18:00, however it is found that the afternoon hours, between 13:00 and 15:00 can be denoted as peak hours. During these hours on average 15% of the daily expected deliveries are delivered per hour, resulting in 6 deliveries per hour between 13:00 and 15:00 for Makro Cumará. Since daily peak hours are most crucial for queueing in the unloading process at Makro stores, these hours will be considered in our research. Thus, the arrival rate for the queueing analysis for the current process at Makro Cumará is determined to be $\lambda = 6$. The average service rate for unloading trucks is currently estimated at 40 minutes ($1/\mu = ⅔$) for an average truck size of 32 m^2, with service times varying from 25 to 55 minutes. The store has 8 docks for unloading trucks, however these are rarely utilized all at once. Mostly, only 4 docks are operated at once. This is primarily because operating more docks is not always necessary and does come with additional operating costs. Also, often docks are utilized to create additional storage capacity by placing a container at the dock for a longer period of time. For this analysis, the amount of operational unloading docks (s) is varied in order to determine the optimal number of operational docks.

Analysis criteria are server utilization, waiting time in queue, number of trucks in queue and service level. When server utilization is low, operational costs are incurred at low efficiency. Thus, it is advisable to keep server utilization above 0,7 for a satisfactory efficiency / costs ratio. Also, the server utilization should always be lower than 1, since this value for server utilization results in an unstable, unbound queue, meaning the queue is always busy and the queue grows uncontrollably as long as the arrival rate of customers does not decrease. Furthermore, Makro wishes to service 75% of the suppliers within half an hour of their arrival, also keeping the expected waiting time in queue below 30 minutes, and minimizing the number of trucks waiting in line to 6, which is the maximum parking space. Also exceptional peaks during peak hours should be considered, resulting in the criterium that when all docks are operated, the system should be able to handle double the arrival rate commonly occurring during peak hours.

		S4	S5	S6	Max: S8
ρ	Server utilization	1,00	0,80	0,67	0,92
C (s ,λ/μ)	Probability of waiting	1,00	0,55	0,28	0,75
Wq	Expected waiting time in queue (min)	/	22	6	45
Lq	Expected number of trucks in queue	/	2	1	8
W (0,25)	Service level for t = 15 min	0%	62%	87%	42%
W (0,50)	Service level for t = 30 min	0%	74%	94%	55%
W (1,00)	Service level for t = 60 min	0%	88%	99%	72%

Figure 2.5: Queueing analysis for current process Makro Cumará

As can be seen in Figure 2.5, a queueing analysis is performed for a situation with 4 to 6 operational docks. In the situation with 4 operational docks, which is common practice at Makro Cumará, it can be seen that the server utilization is 1. The resulting uncontrollable growth of the queue occurs almost daily during peak hours. Often, this has the result that trucks will have to queue long periods of time, even on the street outside the parking area as pictured in Figure 2.6, until the arrival rate drops. Thus, during peak hours it would be advisable to utilize at least 5 unloading docks, making sure the server utilization is within limits at 0,8. Also, in this way, 74% of the trucks are serviced within 30 minutes, which at 1% below requirement is acceptable due to the fact that average waiting time in queue is 22 minutes. When exceptional peaks occur during peak hours at Makro Cumará, a doubled arrival rate of 12 trucks per hour can be expected (λ = 12). When all 8 docks are operational, the server utilization of 0,92 shows the unloading docks have enough capacity to unload every truck without the queue growing uncontrollably.

Figure 2.6: Average peak hour with unbound queue

Concluding, for the current situation at Makro Cumará 4 operational unloading docks during peak hours consistently leads to unstable and uncontrollably growing queues. When 5 unloading docks are operated, requirements for server utilization, waiting time, number of trucks in queue and service level are met during peak hours. Lastly, with 8 unloading docks, exceptional peaks can be handled at Makro Cumará.

3. Makro strategy

At Makro Colombia, every five years a multiannual strategy is determined, containing a series of actions and focus points, formulated to reach a certain goal in the set time period. In the strategy of Makro Colombia for 2016-2021, six strategic pillars are defined:

- Focus on people
- Focus on sales
- Passion for the customer
- Efficient business management
- Improved Information systems
- Expansion

The last three of the mentioned pillars share common ground and the execution of these pillars is brought together in the biggest reformation project in the history of Makro Colombia: the M40+ project. The strategy of the M40+ project and the key innovations are discussed in the following paragraphs.

3.1 Overview of M40+ Project

Makro Colombia currently faces several problems such as low service levels, high levels of inventories and low productivity in the process of receiving merchandise. Besides that, given the positive macroeconomic conditions and growth in consumption in the cash-and-carry business, Makro has planned to expand its operations by opening nine new stores in Colombia by the end of 2021, resulting in a total of twenty-six stores. The current problems and the planned expansion force Makro to come up with a new system that provides a more efficient solution for operations between suppliers and Makro in order to transfer the benefits of the growing market to Makro's clients.

In Figure 3.1, a visual representation of the future supply chain of Makro is given. As can be seen, the first and most obvious innovation in the future supply chain of the M40+ project is the addition of a cross-docking center (CDC). A cross docking operation is a logistics procedure where products from a supplier are distributed directly to the retail chain with marginal to no handling or storage time. Cross docking takes place in a distribution docking terminal; the cross docking center. In Paragraph 3.2, the operations of the CDC will be further elaborated upon. The second innovation in the M40+ project is the implementation of new retail software by the name of Oracle, which will replace the old MBS software. With the introduction of the new retail software, the orders will all be placed by HO, which has real-time information on stock levels in stores. The Oracle system will be implemented in a phased manner, gradually increasing the dependency of Makro on the new system, in 4 releases. In this report, the focus is upon release 3, which is the last release in which MBS is still functional for some of the processes. In Paragraph 3.3, the new retail software in release 3 will be further elaborated upon.

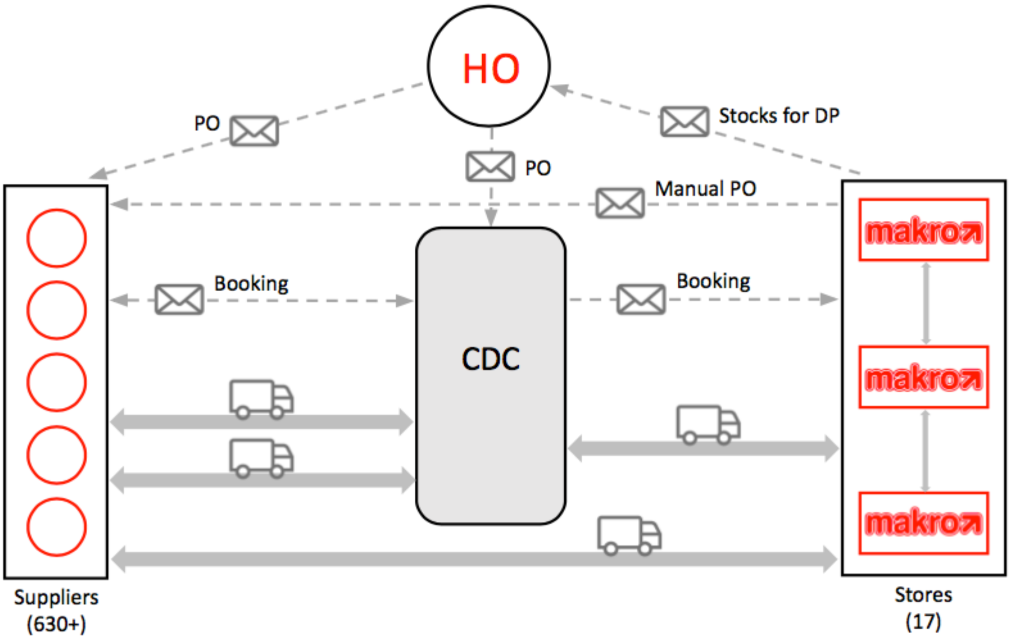

Figure 3.1: Future supply chain process for dry-food and non-food

3.2 Cross Docking Implementation

Makro will open a Cross Docking Center in Colombia in 2018. A CDC usually consists of an inbound side and an outbound side, both with docking doors for unloading or loading trucks. The name ‘cross docking’ explains the process of receiving products through an inbound dock and then transferring them across the dock to the outbound transportation dock with transformation processes when needed. The implementation of a CDC should ensure more efficient and economical operations, because it enables consolidation of orders of different suppliers in a single vehicle. Among other things, this should shorten transportation times and distances, and the duration of product repositioning in stores. In addition, stores will be able to reduce their storage space in warehouses and increase their productivity, which will both lead to more efficient processes and thus stores will be able to ensure the prompt availability of products on the sales floor. Also, the implementation of the so-called Certificate of Entry will ensure faster handling of suppliers. This certificate can be gained by suppliers when they consistently deliver the right quantity and quality of products, which means the supplies they deliver will not have to be completely checked every time they deliver, saving time for the supplier and Makro.

The CDC will be used for the cross docking of dry-foods (DF) and non-foods (NF). About 61% of the total volume of DF and NF products transported is potentially centralizable, thus the CDC will service about half the suppliers of Makro Colombia. Products considered non-centralizable are among others local products only consumed in certain areas of Colombia. A third-party logistics (3PL) company will be contracted to operate the CDC and with whom the full project will be developed in terms of operations and indicators. The CDC will be located in the capital of Colombia, Bogotá, and transportation from CDC to stores will be done by a contracted transporter.

3.3 Foreseen Digital Infrastructure

Having optimized their cost quantification and their product pricing foundations in Releases 1 and 2 respectively, the M40+ programme is currently concentrating on improving its demand forecasting capabilities whilst improving their overall information provision in the supply chain. These two difficult aspects will be tackled in the M40+ Release 3, which is due to be launched by the end of April 2018. In this release, the digital infrastructure of Makro will be radically overhauled.

The plans for Release 3 are split across two departments that mutually exchange information;

1. *Demand planning* – functionalities related to causal forecasting and business intelligence will enable optimal automated quantification of needs
2. *Supply chain* – functionalities related to auto-replenishment, allocation, transfers and imported items will need to be implemented to facilitate cross docking implementation

For each of these departments to obtain the functionalities they need, Makro and Oracle have selected modules that will need to be customized and implemented in the course of Release 3. These include the following modules: *Retail Demand Forecasting* (RDF), *Replenishment*, *Business Intelligence* (BI), *Retail Trade Management* (RTM), *Allocation* and *Retail Merchandising System* (RMS). An overview of these modules will be discussed and analyzed in Section 4.1.

The placement of orders at suppliers will change from MBS-directed to Oracle-directed. This implies that interfaces for digital communication will need to be developed between Makro and both the suppliers and the new 3PL. The Supply chain department will require of each of the suppliers that deliver to the CDC that they communicate via electronic data interchange (EDI), an interface that allows for rapid and instantaneous exchange of information. Furthermore, Makro will need to set up a special set of interfaces for its communication with the 3PL at the cross docking center. The 3PL's Warehouse Management System (WMS) will need to be coupled to Makro's Oracle system of modules. It is important that these two parties can instantaneously keep each other notified of the status of certain ordered SKU's, so as to be able to follow them throughout the supply chain process.

As a whole, Release 3 of Makro's M40+ programme will prove particularly challenging. It will require integration and communication between various types of electronic software; MBS, Oracle, a Warehouse Management System, and the individual softwares of over 500 suppliers. An adequately functioning digital structure can only be acquired if each separate module is implemented incrementally upon thorough testing.

4. Analysis and Design of Future Situation

4.1 Analysis

4.1.1 Quantification of Needs

In order to optimize the process of quantification of needs, the supply chain process and the digital flows of information have been re-evaluated and re-designed. Where the individual Makro stores have held a pivotal position in their quantification of needs through the OPL-MST-MHO process, the responsibility will shift towards Makro HO in the course of Release 3.

The quantification of needs procedure has been categorized in such a way that three different entities carry the final responsibility over three different sets of SKU's. Envisaged is that roughly 70% of the sales of Makro will be quantified through an automated module; 20% will be defined manually by HO; and 10% of sales are defined by the store managers. The scope of this investigation lies in the former two.

Module	**Function**
Retail Demand Forecasting (Oracle)	The RDF module is used to quantify the stock needs per SKU per store. RDF uses two years of historical data and makes forecasts of necessary stock levels for the upcoming 13 weeks. *Inputs:* Stock levels of selected SKU's per store *Outputs*: Forecasts of stock needs per SKU per store
Replenishment (Oracle)	The Replenishment module optimizes the stock needs per SKU per store based on a set of key performance indicators. The Replenishment module makes use of three algorithms – Dynamic, MinMax and Causal – in order to ensure that all stores stock levels can optimally be replenished according to predefined quantifiable desired outcomes. *Inputs:* Forecasts of stock needs, service levels of suppliers *Outputs:* Automatic and semi-automatic purchase orders

Figure 4.1: Relevant modules for automated quantification of needs

The automatically quantified needs are generated through two modules of Oracle; *Retail Demand Forecasting* (RDF) and the *Replenishment* module. An overview of their functionalities in shown in Table 4.1. The Demand Planning Department at the Makro head office is responsible for the monitoring and improving of the functionalities of RDF and Replenishment. By centrally evaluating the needs of all stores for Makro Colombia, the Demand Planning Department can make far better predictions of individual store needs as underlying business and market mechanisms can be identified through these two Oracle modules. Firstly, stock level needs are quantified in RDF, and subsequently, through the Replenishment module, Purchase Orders (POs) are generated that meet the store's future needs on the one hand, and fit to predicted service levels and wished financial outcomes for Makro on the other.

Module	**Function**
Business Intelligence (Oracle)	The Business intelligence module processes data on stock levels of stores, service levels of suppliers, costs of products and other data to create powerful and visually attractive analytics. It allows individuals to make well-informed business decisions. *Inputs:* Raw data about SKU's and stores *Outputs:* Visually attractive processed data
Retail Trade Management (Oracle)	The Retail Trade Management module allows users to manage the import process of goods into Colombia. It classifies assignments, makes an estimation of peripheral costs, and manages the set of suppliers that provides import goods. *Inputs:* Raw data about import SKU's and stores, import supplier information *Outputs:* Peripheral cost estimations, prognostic purchase orders
Allocation (Oracle)	The Allocation module can simulate orders and quantify the consequences of an envisaged order. It allows for the categorization of orders per individual store and thus is used as a tool to define how different products from a same order should be sent to different stores. *Inputs:* Prognostic purchase orders *Outputs:* Allocation lists (a clear division of which products are sent to which stores)

Figure 4.2: Relevant modules for quantification of needs manually defined by HO

The needs manually quantified by Head Office are generated using three separate, yet mutually interacting modules of Oracle; *Business Intelligence* (BI), *Retail Trade Management* (RTM) and *Allocation*. An overview of their functionalities is shown in Table 4.2. The SKU's that are subject to discounts, promotions, or other forms of marketing are evaluated using BI.

From the data gathered from BI, the Commercial Department at the Makro head office can decide to place PO's with certain optimal quantities and at certain optimal prices. The SKU's that need to be ordered abroad such as large electronic devices and cooking appliances are managed separately through RTM. The *Allocation* module is used to manage the division of ordered SKU's over different stores. It is used as a complement to the RTM module, but its functionality is also applied separate from this module. *Allocation* allows Makro HO to keep track of which SKU's will be sent to which store at every specific time.

4.1.2 Order Placement

All purchase orders originating from the quantification of needs phase are placed centrally in the *Retail Merchandising System* (RMS). This happens during the second phase in the end-to-end supply chain process of Makro. The RMS is a central module in Oracle's software infrastructure which allows to compile and track all information originating from modules named in Section 4.1.2. However, due to Makro's strategy of implementing their changes in a phased manner, not all functionalities of RMS will be implemented initially. This implies that the existing order system, *Makro Business System* (MBS), cannot be removed completely yet. As a result, MBS will serve as the interface through which orders are placed at the supplier via EDI.

Module	**Function**
Retail Merchandising System (Oracle)	The Retail Merchandising System manages, controls and aligns merchandising activities originating from different modules. It allows for orders to be placed through a central interface and allows users to keep track of distribution, order fulfillment and financial close. *Inputs:* Automatic, semi-automatic and manual purchase orders *Outputs:* Final purchase orders, allocation lists, proofs of order
Makro Business System (custom software)	The Makro Business System keeps track of stock levels of stores and provides the network for EDI order placement at selected suppliers. *Inputs:* Purchase orders *Outputs:* Purchase orders sent via EDI

Figure 4.3: Relevant modules for quantification of needs manually defined by HO

4.1.3 Analysis conclusion

From the two previous subsections, the sheer size and ambition of Makro's digital restructuring project is evident. Each of these interfaces needs to be implemented, developed to custom fit Makro's needs and tested to ensure full optimal usage. Knowing what the necessary inputs and outputs of each of the modules are provides insight and understanding to how interfaces between Makro's software and that of suppliers and the 3PL should be structured. Furthermore, it is important to know what modules use information about stock levels and service levels, as this data will also need to flow back into these modules upon distribution and receipt of merchandise.

The overall architecture and hierarchy between different modules is visualized in Figure 4.4. It shows how different departments and entities are responsible for different aspects in the quantification of needs and ordering process. For the design of interfaces, it is interesting to see that all information flows out of the RMS module. These flows will need to be directed towards the suppliers and the 3PL with information about purchase orders. In the design of interfaces process, attention must be paid to what information the suppliers and 3PL will have access to, and how Makro can stay informed of the status of its ordered SKU's.

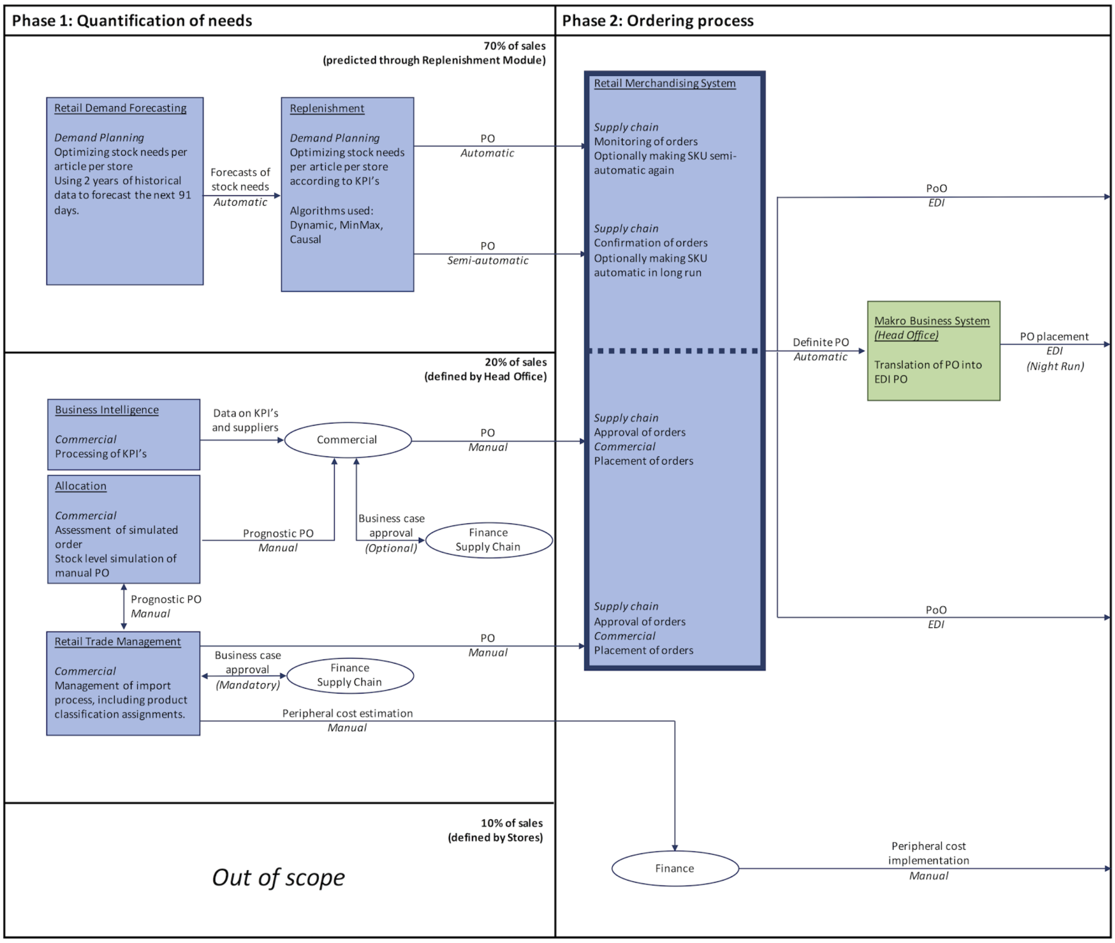

Figure 4.4: Schematic overview of used modules in first two phases of supply chain process

4.2 Design

4.2.1 Distribution of merchandise

From the analysis of the re-designed initial two phases of the end-to-end supply chain process, a clear overview was given that illustrates which information is necessary at which stage in the supply chain. In designing the future information flows for Makro's supply chain, a series of interviews and meeting sessions were held with a number of different departments of Makro. Since there was not yet a Third Party Logistics selected, the focus of the investigation lies on uncovering the expectations of supply chain specialists and experience experts in the field.

In "Phase 3: Distribution of merchandise", the suppliers need to bring the SKU's ordered by Makro to the Cross-Docking Center, which is run by the Third Party Logistics (3PL). From ordering a number of goods to delivering the goods at the Cross-Docking Center, many mistakes can be made or things can go wrong. A control mechanism must be put in place that allows to identify and track whether the number of SKU's Makro has ordered is indeed the number of goods that the supplier delivers at the Cross-Docking Center.

Upon receiving the merchandise at the Cross-Docking Center, the 3PL needs to register the received goods in their system. This is where the contractual obligations of the supplier to Makro end, and so a clear system must be put in place to check the quality and quantity of delivered goods, without the 3PL obtaining insight to the costs Makro is making with the supplier. The initial reception and registration of these SKU's will happen in a Warehouse Management System – a software application that helps control and manage the day-to-day operations in a warehouse. The Warehouse Management System (WMS) is brought in by the 3PL and must be able to register the goods, track their locations within the warehouse, and communicate its stock levels relevant for Makro through to Makro Head Office.

The function of the Cross-Docking Center is to be able to centrally order large quantities of goods, so as to send re-packaged smaller personalized quantities to each individual store according to its individual needs. During "Phase 1: Quantification of needs", Makro will have created allocation lists, which clearly state which ordered SKU's will need to be allocated to which individual store. Makro and the 3PL will have contractually agreed upon an allocation redistribution function, which adjusts the allocation list according to the number of received goods at the Cross-Docking Center. That reallocation will need to be communicated through to Makro HO, so that they know what numbers of goods will be arriving in their stores in due time. This allows Makro to keep a better overview of its store's stock levels, and allows Demand Planning to better predict each store's needs.

The 3PL is responsible for the repackaging process of all goods received at the CDC. Thereupon, the 3PL needs to send a Secondary Dispatch Announcement (SDA) to the Makro store, which allows it to know what SKU's it can expect on which day. This SDA will be used to verify the number of transferred SKU's upon delivery. After forming packets to be sent to Makro's different stores and planning the arrival times transporters will drive to the stores across Colombia, "Phase 3: Distribution of merchandise" comes to an end and the secondary distribution (where goods are transported from the CDC to each relevant store), or "Phase 4: Transfer of merchandise" is initiated.

Based on this brief summary of events resulting from research with experts and specialists, a sequence of events for the Warehouse Management System was created. This sequence of events is shown in Figure 4.5. By sequencing the events in this manner, it provides a good structure to create an elaborate Swimlane diagram of the entire process (see Appendix D), which, in turn, allows to identify the interfaces that need to be created between the Warehouse Management System and other software systems of other actors in Makro's supply chain.

Sequence of events for the Warehouse Management System: 1. Proof of Order (including Allocation List) is received from Makro HO 2. Booking is placed in consultation with relevant supplier 3. Primary Dispatch Announcement is received and processed 4. Based on Allocation List and Primary Dispatch Announcement, a Preliminary Re-Allocation is formulated and sent to Makro HO 5. Goods are received at the Cross-Docking Center 6. Receipt of Merchandise is created based on goods received, Primary Dispatch Announcement, Package List CDC 7. Based on Receipt of Merchandise, a Final Re-Allocation is formulated and sent to Makro HO 8. Primary Dispatch Announcement is created and sent to Makro Store 9. Packets of goods for stores are formed and sent off with transporter
Information that is instantaneously exchanged or updated: ● Stock levels of Cross-Docking Center ● Physical locations of SKU's in the Cross-Docking Center ● Information about suppliers (codes, contact information, etc) and SKU's (codes, categories, etc)

Figure 4.5: Overview of relevant actions for the Warehouse Management System in the Distribution of merchandise phase

4.2.2 Transfer of merchandise

"Phase 4: Transfer of merchandise" is in structure very similar to "Phase 3: Distribution of merchandise". The largest difference between the two is that Phase 4 comprises other actors and as such other information flows and different types of interfaces.

Upon coordinating pickup and distribution times between the 3PL and Makro, the transporters are responsible for transferring the packets of SKU's from the CDC to the Makro stores. As such, a fourth party will be handling the SKU's, that have been purchased by Makro. These transporters will be selected based on their reliability levels, and often will have pre-specified delivery times scheduled at the Makro stores so as to streamline the transfer process. However, once again, adequate control mechanisms must be in place that allow to track the status and state of Makro's ordered SKU's. If an SKU is damaged, wrongly packaged, missing, or erroneously delivered, all the different softwares and interfaces of all different parties involved must together be able to correctly identify the individuals responsible. As such the systems must not only adequately be communicating with each other, they must together create a waterproof structure that collects and accommodates for all types of errors or mistakes that can occur along the path.

As the transporter arrives at the Makro store and unloads its goods, the Makro Business System (MBS) will be used to register the delivered products. MBS, in M40+'s Release 3 will be the system that manages the stock levels of the stores. MBS then communicates its stock levels through to the Oracle Retail Merchandising System, which is subsequently able to coordinate a centralized and effective stock level replenishment through Demand Planning as discussed in Section 4.1.1.

In MBS, "Transfer notices" can be entered on which the number of goods received at the store are recorded. These Transfer Notices are identical to the ones that are being issued in the current situation when one store sends a set of its SKU's to another. As such, no new interfaces must be implemented for this communication line, but a clear outline must be provided to ensure that the transporter and the 3PL are able to work with these same documents and are able to adequately receive these electronically in their respective information systems.

Total unique key input datasets

1. PO reference number
2. 3PL reference number
3. Transporter reference number
4. Makro Global Location Number and name
5. Supplier code and name
6. SKU code and name
7. Quantity per SKU ordered
8. Quantity per SKU to be delivered at CDC
9. Quantity per SKU to be delivered at store
10. Quantity per SKU delivered at CDC
11. Costs per SKU
12. Shipping address
13. Type of order: promotional/normal
14. Allocation (SKU quantity, store number)
15. Boxes or pallets
16. Type of truck
17. (Re-)allocation (SKU quantity, store number)
18. Signed RoM (including NoD)
19. Delivery date and time at store
20. Delivery date and time at CDC

Figure 4.6: Necessary key inputs for all interfaces in Phases 3 and 4 of supply chain process

Lastly, if the number of SKU's that were announced in the Secondary Dispatch Announcement differ from the number of SKU's that are received at the store, this means that something may have gone wrong during the transportation process. The Transporter thus needs to be held accountable. Therefore, a claim document will need to be made. Since Makro has already paid for the SKU's, the transporter will need to credit the resulting damage to Makro's Finance department. The latter is responsible for the monitoring and controlling of outstanding debit and credit notices.

Oracle and Supplier 1. PO reference number 2. Makro Global Location Number and name 3. Supplier code and name 4. SKU code and name 5. Quantity per SKU ordered 6. Costs per SKU 7. Shipping address 8. Type of order: promotional/normal	*WMS and Supplier* 1. PO reference number 2. Supplier code and name 3. Delivery date and time at CDC 4. SKU code and name 5. Quantity per SKU to be delivered at CDC 6. Boxes or pallets 7. Type of truck
WMS and Oracle 1. PO reference number 2. Supplier code and name 3. SKU code and name 4. Quantity per SKU ordered 5. Allocation (SKU, quantity and store number) 6. Type of order: promotional/normal 7. Quantity per SKU to be delivered at store 8. (Re-)allocation (SKU quantity, store number) 9. Delivery date and time at store 10.Quantity per SKU delivered at CDC 11.Delivery date and time at CDC 12.Shipping address 13.Signed RoM (including NoD)	*WMS and MBS* 1. 3PL reference number 2. Transporter reference number 3. SKU codes and names 4. Quantity per SKU to be delivered at store 5. Delivery date and time at store 6. Boxes or pallets 7. Truck type

Figure 4.7: Necessary key input per interface in Phases 3 and 4 of supply chain process

The above text globally summarizes the different information flows and different actors that are involved in Phase 4 of Makro's end-to-end supply chain process. It is clear that many different parties will need to exchange information in order to ensure optimal deployment of the Cross-Docking Center. By slowly taking into account the architecture of the different softwares and by taking integrating the different functionalities and necessities of each of the different information systems, an overall mapping of Makro's end-to-end process in terms of information flows could be created. By creating a Swimlane diagram of this fourth and final Phase, and walking through the entire process step by step, a set of systems and interfaces could be designed to accommodate for all the boundary conditions stipulated by experts and supply chain specialists throughout the design process.

This Swimlane diagram (see Appendix D) subsequently enabled the researchers to identify key information sets that must be exchanged between different parties. In the design of the flow of information of Makro's supply chain, it is very important to differentiate between the dissimilar information sets that the different actors will be exchanging. As such, twenty unique necessary key input datasets were identified that need to be exchanged between different parties; see Figure 4.6. Furthermore, Figure 4.7 shows which key inputs are needed across which interface. This identification provides the different IT teams overseeing the design of information process with crucial information so as to properly design the different interfaces.

4.2.3 Design conclusion

Sections 4.2.1 and 4.2.2 clearly outline the boundary conditions needed for an effective collaboration between Makro Head Office, Makro stores, Suppliers, the Third Party Logistics and the Transporters. By structuring information flows along separate modules handled by separate actors, and walking through the entire end-to-end process step by step with experts and supply chain specialists, an overview of flow of information can be created – see Figure 4.8.

This overview is the result of many iterations within the design process and successfully embodies all different needs and expectations set by the Makro Supply Chain, Demand Planning, Finance and Logistics departments. Figure 4.8 complements Figure 4.4 which shows a schematic overview of the modules in the first two phases of the supply chain process. Together, these two Figures provide a roadmap for how information will flow in Release 3 of Makro's M40+ project.

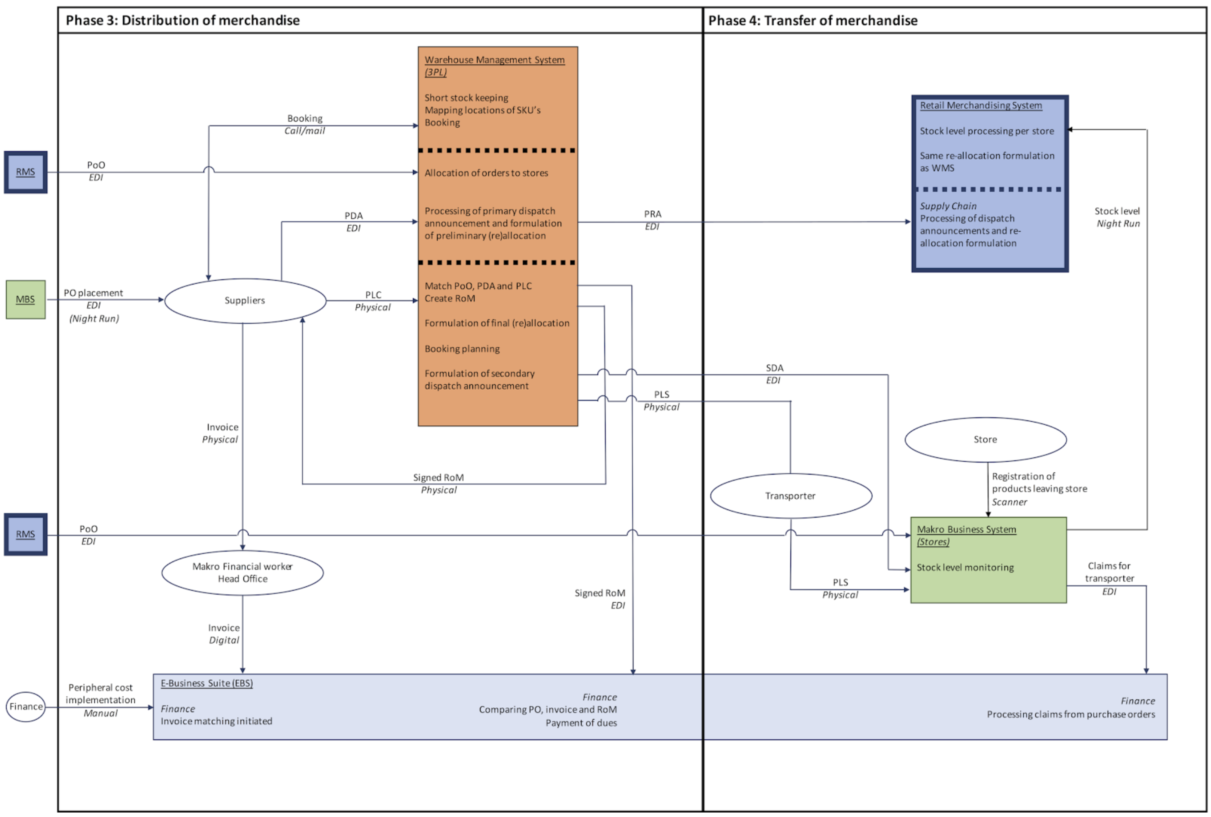

Figure 4.8: Schematic overview of used modules in last two phases of supply chain process

4.3 Traffic Flow: Future Delivery and Queueing Analysis

It is important for a company to know the benefits certain changes have in comparison with the old situation. Makro Colombia expects that with the CDC, less trucks are needed to deliver the same goods. Therefore, the goal of this section is to calculate the total number of deliveries for two future delivery process scenarios: one with and one without a CDC.

These numbers will also be used as an input for another analysis. When the expected number of incoming- and outgoing deliveries for the CDC are known, it is possible to determine the amount of loading docks and parking spots needed by applying Queueing Theory.

In this section the total number of deliveries in the future situation with and without a CDC will be estimated. By analysing the results such as the difference in total deliveries or total deliveries per supplier per month, the positive effects of a CDC can be visualised in actual numbers. Figure 4.9 gives a good overview of the two scenarios being compared.

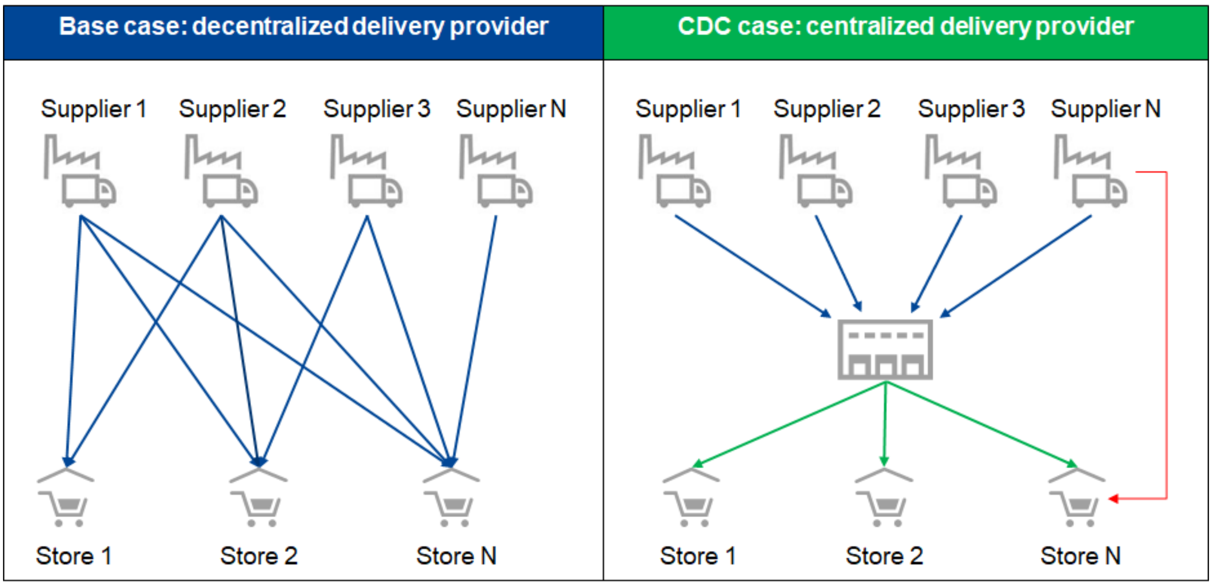

Figure 4.9: Centralized and decentralized concept illustrated

To compare two different scenarios in the future, a particular year needs to be selected that serves as a base case. In section 4.3.1, the base case is selected and the data needed for this analysis is discussed. Paragraph 4.3.2 describes the data processing and the assumptions made in the process. The future delivery analysis results will be presented in paragraph 4.3.3. The required parking space is estimated in 4.3.4 and the queueing theory is applied in 4.3.5. In the same paragraph, the amount of loading docks needed in the CDC will be calculated.

4.3.1 Selection of base case scenario

To select a base case year, it is important to know what data is available to make the estimations as accurate as possible. Makro Colombia has plans to build nine additional shops throughout Colombia in the next 5 years. Supply chain and the commercial department already made estimations of the expected volume per supplier per store in 2021. In combination with the data about suppliers and stores in 2016, see paragraph 2.2, there was enough data to conduct the future delivery analysis. Together with supply chain, the year 2021 was selected as our base case as shown in Figure 4.10.

Figure 4.10: Selection of base case

When the base case was selected, additional information needed to be gathered such as the expected volume per supplier per store in 2021. The estimations are presented in Figure 4.10.

	Year				
	2017	2018	2019	2020	2021
Number of suppliers	434	434	434	434	434
Volume transported per month (m3/month	46864	51065	55507	60513	66283

Figure 4.11: Expected growth of demand

For this analysis, the excel file 'Analysis of all incoming NF and DF deliveries' was expanded with the new data.

4.3.2 Data processing and assumptions

The following section describes the data processing of the two scenarios and the assumptions made in the process.

Base case scenario: decentralized delivery provider

With data about the expected cubic meters per supplier per month in 2021 and data about the frequency of monthly delivery per store, it was possible to estimate the number of deliveries per month per supplier in 2021. The data processing was pretty easy for the base case scenario without a cross-docking center, because it was the same procedure as done in paragraph 2.2.

However, for these estimations, two assumptions had to be made. The first one is that the number of suppliers does not increase or decrease in respect to 2016. This is likely to change, but hard to predict. The second assumption concerns the number of deliveries per store. This number will does not increase or decrease in respect to 2016 for the 17 current Makro stores. Nonetheless, the total amount of deliveries per supplier per month increased due to the fact that the number of stores increases from 17 to 26.

CDC case scenario: centralized delivery provider

The future delivery analysis for the second scenario, with a fully operational CDC, was harder to conduct. In order to determine the future transportation flows, the raw data needed to be processed. Not every supplier is able or willing to make the change to go to the CDC instead of directly to the stores. The suppliers had to be divided into centralizable and non-centralizable in consultation with supply chain. Initially, the full list contained 434 suppliers. In several interviews with various departments, four main filters were chosen to get a list of the centralizable suppliers. In the excel file 'Analysis of all incoming NF and DF deliveries' in the sheet 'Selection of suppliers for CDC', four columns were created containing the four filters. These four filters were applied:

1. The first column (filter) contains a list (provided by supply chain) of 60 suppliers which are not centralizable. Most of these are not willing to make the change to go to the CDC instead of transporting the goods directly to the stores.
2. The second column filters the suppliers which are not fully centralizable.
3. Makro headquarters determined that import NF and DF goods would not be transported from the harbour via the CDC to the stores in 2021. These import suppliers were also excluded from the centralizable list.
4. Suppliers who produce only regional products (only used in certain parts of the country) will not deliver to the CDC. For example, some popular regional products were produced around the city Cali and only consumed in this part of the country as well. It would be a waste of resources to transport these products to the CDC and directly back to Cali. Therefore, these suppliers were also excluded from the list.

Out of the 434 candidate suppliers, 335 were centralizable and for 99 suppliers it was not possible or feasible to deliver goods to the CDC. That means that, in this scenario, 99 suppliers (producing 42.82% of the total volume) will continue to deliver their goods directly to the stores and the rest of the suppliers (producing 57.18% of the total volume) will deliver to the CDC. In Figure 4.11, this distribution is presented in a graph.

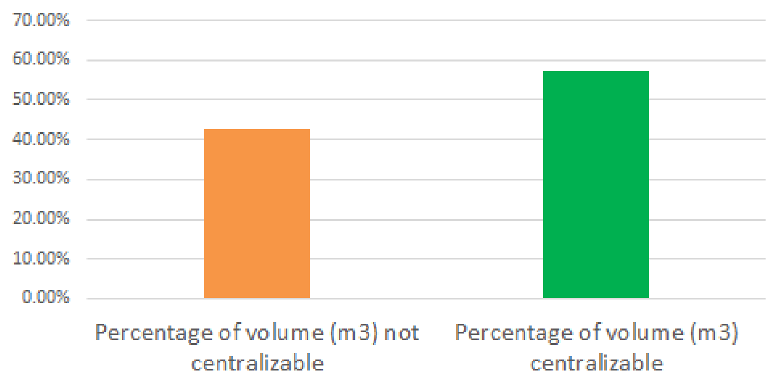

Figure 4.12: Percentage of centralizable volume possible to transport via CDC

Having determined the suppliers transporting goods to the CDC in the future delivery system, assumptions were made to calculate the total number of deliveries. One of the major benefits of a CDC operation, is that suppliers can deliver several orders from Makro stores in

one truck to the CDC. Therefore, the number of Full Truck Loads (FTL) increases tremendously when a CDC is operational.
The first assumption that had to be made was that the trucks, driving from the suppliers to the CDC, are always fully loaded, except for the last truck. The suppliers are using 5 different trucks. Luckily, supply chain was able to create a list with the truck types used per supplier. The following five truck types are used in this analysis:

Type of truck	Capacity (m3)
Mula	67
Sencillo	34
Turbo	24
Nkr	16
Nhr	11

Figure 4.13: Truck types used in this analysis

The second assumption concerns the total number of deliveries from the CDC to the stores. All the goods, delivered by the suppliers, need to be divided into groups and transported to every store. That means that the same amount of goods, transported by the suppliers, is transported by the 3PL from the CDC to the Makro stores. As these trucks will contain multiple goods, it is easy to fill a truck until it is full. The truck type used by the 3PL has not been determined yet. In this analysis, the largest truck in Figure 4.12, the 'Mula', has been chosen to serve as the truck type of the 3PL.

4.3.3 Delivery analysis results

At this point, the relevant data was processed and the results of the delivery analysis of the two scenarios could be made. For the base case scenario, the total number of deliveries contains one number as there is only one transportation line: from the suppliers directly to the stores. For the CDC case scenario, there are three transportation lines: from the supplier to the CDC from the CDC to the stores and from the suppliers directly to the stores. In Figure 4.13, the total amount of these three lines is shown.

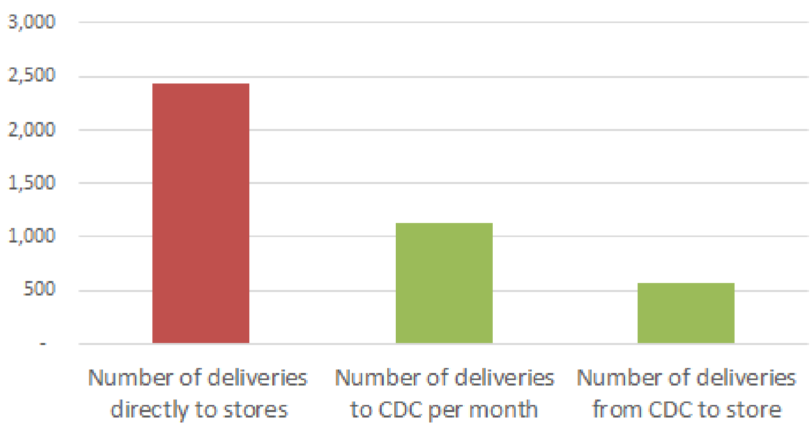

Figure 4.14: CDC case scenario deliveries of the three transportation lines

As you can see in the results of the CDC case scenario above, the majority of the deliveries is still from the suppliers directly to the stores. Because of full truck loads going from the suppliers to the CDC and from the CDC to the stores, 57.18% of the total volume is transported in 1704 deliveries. The rest of the volume, 42,82%, is transported in 2442 deliveries. The great benefits of having a CDC are already visible in this scenario. Comparing these results with the other scenario, the base case scenario without a CDC, will make these benefits even more clear.

In Figure 4.14, the delivery analysis results of the two scenarios are presented. The results are divided into three groups of suppliers: suppliers delivering 1-4 times each month, 4-8 times or over 8 times. The total number of deliveries per scenario are shown in the last two bars.

Figure 4.15: Total number of deliveries per month for both scenarios in 4 categories

The total number of deliveries in every category is substantially higher in the base case scenario in respect to the CDC case scenario. Especially in the first category, suppliers delivering 1-4 times a month, the difference is significant. Some of these suppliers deliver small amounts of goods to each store and need to transport these goods to each and every store. With a CDC, these type of suppliers can deliver one large truck to the CDC containing all their goods. Therefore, the average deliveries per supplier per month will be substantially lower when a CDC will be fully operational, Figure 4.15 shows this conclusion clearly.

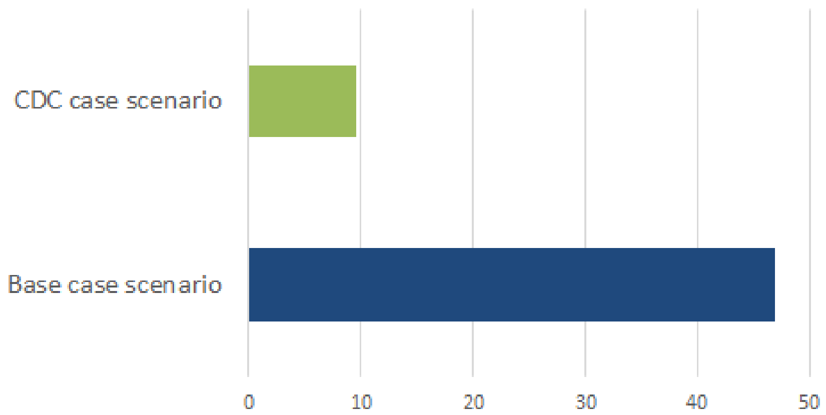

Figure 4.16: Average deliveries per supplier per month

Due to this large improvement in efficiency, the total deliveries with a CDC in 2021 will be 80% less than in a future situation without a CDC as can be seen in figure 4.14. These results and the calculation of these results can be found in the excel file 'Analysis of all incoming NF and DF deliveries'.

4.3.4 Queueing at Stores and CDC

In this section, the future situation with a CDC will be analyzed with the queueing theory in order to define the number of required unloading and loading docks at the CDC. Also, the impact of the implementation of the CDC on stores will be analyzed, again using Makro Cumará as an example.

At the inbound docks of the CDC, all centralizable DF and NF suppliers are expected to deliver 1138 times a month, resulting in 38 deliveries per day and 6 deliveries per peak hour ($\lambda = 6$). These are less deliveries than might be expected when approximately half of the total delivered volume is now delivered to the CDC, however this is due to the increasing drop size of the trucks: the supplier trucks carry higher volumes per delivery. The service time is reduced, due to the Certificate of Entry, however the higher volumes of goods in the trucks decrease this positive effect. As a result, the service time is only slightly reduced to 30 minutes per truck ($1/\mu$ = ½) for an average truck size of 32 m^2, with service times varying from 25 to 40 minutes. For this analysis, the amount of operational unloading docks (s) is varied in order to determine the optimal number of operational docks.

		S3	S4	S5	S6
ρ	Server utilization	1,00	0,75	0,60	0,92
C (s ,λ/μ)	Probability of waiting	1,00	0,51	0,24	0,78
Wq	Expected waiting time in queue (min)	/	15	4	47
Lq	Expected number of trucks in queue	/	2	0	9
W (0,25)	Service level for t = 15 min	0%	69%	91%	39%
W (0,50)	Service level for t = 30 min	0%	81%	97%	53%
W (1,00)	Service level for t = 60 min	0%	93%	100%	71%

Figure 4.17: Queueing analysis for 2021 process inbound CDC

As can be seen in Figure 4.16, a queueing analysis is performed for a situation with 3 to 5 operational docks. In the situation with 3 operational docks, it can be seen that the server utilization is 1, which would result in uncontrollable growth of the queue. Thus, during peak hours it would be advisable to utilize at least 4 unloading docks. The server utilization will be slightly below the 0,8 limit, which is the maximum reachable utilization under 1. Also, in this way, 81% of the trucks are serviced within 30 minutes and average waiting time in queue is 15 minutes. When exceptional peaks occur during peak hours at the inbound side of the CDC, a doubled arrival rate of 12 trucks per hour can be expected ($\lambda = 12$). To guarantee sufficient capacity during exceptional peaks, 6 docks are required and gives a server utilization of 0,92 at that moment. Also, the expected number of trucks in queue during high server utilization shows that at least 9 parking spots for waiting trucks are required at the inbound side of the CDC.

At the outbound docks of the CDC, the transporter is expected to collect 566 truckloads per month for transport to Makro stores. These are far fewer than the number of incoming deliveries, which is due to the bigger truck size of the transporter trucks. The 566 monthly trips result in only 19 trips per day, which leads to 3 trips during peak hours ($\lambda = 3$). Due to the size of the trucks and the goods not always being ready for shipment at the required moment, the service time of transporter trucks at outbound docks is expected to be 45 minutes per truck ($1/\mu = ¾$) for an average truck size of 38 m^3, with service times varying from 40 to 60 minutes. For this analysis, the amount of operational unloading docks (s) is varied in order to determine the optimal number of operational docks.

		S3	S4	S5	S5
ρ	Server utilization	0,75	0,56	0,45	0,9
C (s ,λ/μ)	Probability of waiting	0,57	0,24	0,09	0,76
Wq	Expected waiting time in queue (min)	34	6	1	69
Lq	Expected number of trucks in queue	2	0	0	7
W (0,25)	Service level for t = 15 min	56%	87%	96%	35%
W (0,50)	Service level for t = 30 min	66%	92%	99%	45%
W (1,00)	Service level for t = 60 min	79%	98%	100%	61%

Figure 4.17: Queueing analysis for 2021 process outbound CDC

As can be seen in Figure 4.17, a queueing analysis is performed for a situation with 3 to 5 operational docks. In the situation with 3 operational docks, the server utilization is above the 0,7 limit. However, it can be seen that the expected waiting time in queue is over the 30 minute limit. Having 4 docks operational would guarantee that the expected waiting time is only 6 minutes, which would be within limits, but this would result in the very low server utilization of 0,56. In this situation, probably the utilization of 3 loading docks would turn out to be most efficient, giving a slightly long waiting time for trucks, but a very acceptable server utilization. When exceptional peaks occur during peak hours at the outbound side of the CDC, a doubled arrival rate of 6 trucks per hour can be expected ($\lambda = 6$). To guarantee sufficient capacity during exceptional peaks, 5 docks are required and gives a server utilization of 0,9 at that moment. Also, the expected number of trucks in queue during high server utilization shows that at least 7 parking spots for waiting trucks are required at the outbound side of the CDC.

At the stores, in the future situation with CDC, a total of 5267 monthly deliveries are expected, consisting of 556 deliveries coming from the CDC, 2259 deliveries of fresh food and 2442 deliveries of non-centralizable DF/NF suppliers. Again the Makro Cumará store will be taken as example, where 15 daily deliveries occur, which leads to 2 deliveries during peak hours ($\lambda = 2$). Due to the use of the Certificate of Entry, unloading happens faster than before. However, due to the larger average truck size of 38 m^2, the average service time remains 30 minutes per truck ($1/\mu = ½$), with service times varying from 25 to 40 minutes. For this analysis, the amount of operational unloading docks (s) is varied in order to determine the optimal number of operational docks.

		S1	S2	S3	S8
ρ	Server utilization	1,00	0,50	0,33	0,31
C (s ,λ/μ)	Probability of waiting	1,00	0,33	0,09	0,00
Wq	Expected waiting time in queue (min)	/	10	1	0
Lq	Expected number of trucks in queue	/	0	0	0
W (0,25)	Service level for t = 15 min	0%	80%	97%	100%
W (0,50)	Service level for t = 30 min	0%	88%	99%	100%
W (1,00)	Service level for t = 60 min	0%	95%	100%	100%

Figure 4.18: Queueing analysis for 2021 process Makro Cumará

As can be seen in Figure 4.18, a queueing analysis is performed for a situation with 1 to 3 operational docks. In the situation with 1 operational dock, it can be seen that the server utilization is 1, which would result in uncontrollable growth of the queue. Thus, during peak hours it would be advisable to utilize at least 2 unloading docks. In this case, the server utilization with 0,5 is below the 0,7 limit, however this situation is prefered over the situation with an uncontrollable growing queue. In the situation with 2 unloading docks, the average waiting time is 10 minutes. When exceptional peaks occur during peak hours at the outbound side of the CDC, a doubled arrival rate of 4 trucks per hour can be expected ($\lambda = 4$). When all 8 docks are operational, the server utilization of 0,31 shows the unloading docks have more than enough capacity to unload every truck without the queue growing uncontrollably. Also, the expected number of trucks in queue during high server utilization shows in most cases parking spots for waiting trucks are not required at the Makro Cumará store.

Concluding, for the future situation at the inbound docks of the CDC, it is advisable to have 6 unloading docks to withstand exceptional peaks. During standard peak hours, having 4 unloading docks operational is sufficient and 9 parking spots gives room for the queueing trucks to park. For the outbound docks at the CDC, 5 loading docks provide sufficient capacity during exceptional peaks. During standard peak hours, having 3 loading docks operational is sufficient and 7 parking spots are required for queueing trucks. At the Makro Cumará store during standard peak hours, having 2 unloading docks operational gives sufficient capacity. Also, the 8 docks give enough capacity in the case of exceptional peaks and parking spots seem unnecessary.

5. Implementation of Design

After creating the optimal design for the information flows of the future supply chain process, it is important to consider the implementation of this design. The largest part of the implementation will consist of testing the information exchange between all systems to make sure that the complete design will function properly in the end.

Therefore, it is necessary to first select the exact flows of information that need testing. It is assumed that the communication between different modules within a system is already tested, which means that the information flows remaining for testing are those between the four different systems (Oracle, WMS, MBS and supplier software). This leads to the following flows of information selected for the testing phase:

Information Flow		**Sending**	**Receiving**
a)	Purchase Order (PO)	Oracle	Supplier
b)	Proof of Order (PoO)	Oracle	WMS
c)	Primary Dispatch Announcement (PDA)	Supplier	WMS
d)	Preliminary (Re-)Allocation (PRA)	WMS	Oracle
e)	Receipt of Merchandise (RoM)	WMS	MBS
f)	Secondary Dispatch Announcement (SDA)	WMS	MBS

In order to be able to make an accurate and realistic estimation of the implementation, testing types and testing times combined in a testing protocol need to be taken into account. The five types of testing that were considered for the testing protocol are Smoke Testing, System Test (ST), System Integration Test (SIT), End-To-End (E2E) test, Performance Test (PT) and User Acceptance Test (UAT). Of these tests the SIT and E2E test were selected as the types that cover the testing of the communication flows described above.

SIT takes place after all individual software components are tested and it is meant to test the required interactions between all components of the entire system (ISTQB Exam Certification, 2016). Furthermore, the objective of SIT testing is to make sure that the dependencies of all components function correctly and that data is transferred between the modules with integrity (ISTQB Exam Certification, 2016).
An E2E test is used to test the entire system when it is assumed to be almost ready for its commercial release (Exforsys, 2011). By doing this test, the complete system gets checked in an ambiance that imitates the real world use. These tests are often done manually, since automating this process is very expensive (Exforsys, 2011).

The goal of this part of the research is to provide Makro with input for the SIT and E2E test. The testing itself is not a part of this research but will be done by the IT department of Makro based on the recommendations described in this report. Another goal is to deliver a planning containing testing times, testing order and key milestones. Input for the SIT is described in paragraph 5.1, input for the E2E in paragraph 5.2 and the planning of the complete testing protocol is described in paragraph 5.3.

5.1 Interface Testing

By describing the procedure of interface testing, input is provided for the SIT. The goal of this SIT is to perform an overall test of a complete system consisting of many subsystems. Therefore, it is first important to determine the exact goal of each information flow and after that, based on these goals, the key information should be identified that needs to be exchanged between the different systems. This key information is called key input and is to be found in Appendix E for each information flow. An example of interface testing for an information flow is shown in Figure 5.1.

For each information flow a table is provided that describes a number of business scenarios. A business scenario simply represents a requirement that the system should be able to meet. However, some requirements are outside the scope of Makro and are therefore marked as 'preferable' in the last column. In the third and fourth column it is indicated to which of the communicating systems the specific business scenario applies. If a business scenario is commented on with "happy path", it concerns a requirement that represents the complete positive scenario. The "happy path" is a term used in the context of software and information modelling which describes "those sequences of activities that will be executed if everything goes as expected without exceptions" (Bollen, 2010).

e) Receipt of Merchandise (RoM)

Goal of communication: Updating financial department about delivered SKU's

Key Input:
1. PO Reference number
2. Supplier code and name
3. SKU code and name
4. Quantity per SKU delivered at CDC
5. Delivery date and time at CDC
6. Shipping address
7. Signed Receipt of Merchandise (including Notice of Difference)

#	Business Scenario	WMS	MBS	Comments
1	RoM message is received and key input is readable	X	X	'Happy Path''
2	RoM message can only be sent after PLC is processed in WMS	X		
3	3PL needs to receive *failed message* notification, when RoM message is not sent	X		
4	Multiple RoM messages need to be able to be sent and received at the same time	X	X	
5	After sending RoM, the status interface needs to change to the status *goods received at CDC*	X		Preferable

Figure 5.1: Example of interface testing for Receipt of Merchandise

The detailed descriptions of the business scenarios can be used in the testing phase to simply check all required abilities of the interfaces of the different systems. By means of these requirements, the absolute boundary conditions are set for each information flow to function properly. If a system meets all business scenarios, it passes the SIT within the testing phase.

5.2 Scenario Testing

By describing the procedure of scenario testing, input is provided for the E2E test. An E2E test is performed after an SIT. The goal of an E2E test is to ensure that the integrated components of a system function as expected, which is done by testing a real-world scenario.

To be able to perform an E2E test and expose the complete system to real-world scenarios, all possible scenarios need to be identified. This is done by first locating the exact sources of error within the chain of events. All sources of errors are under the responsibility of three actors: the supplier, the 3PL and the transporter. At every source of error several kinds of mistakes are possible concerning the amount of SKU's compared to the amount of SKU's ordered, namely: same, less, impossible or more. When all these mistakes are set against each other, it turns out that 49 different scenarios exist ($2^4 \times 3 + 1 = 49$). In Figure 5.2 it is shown how these scenarios were built up schematically.

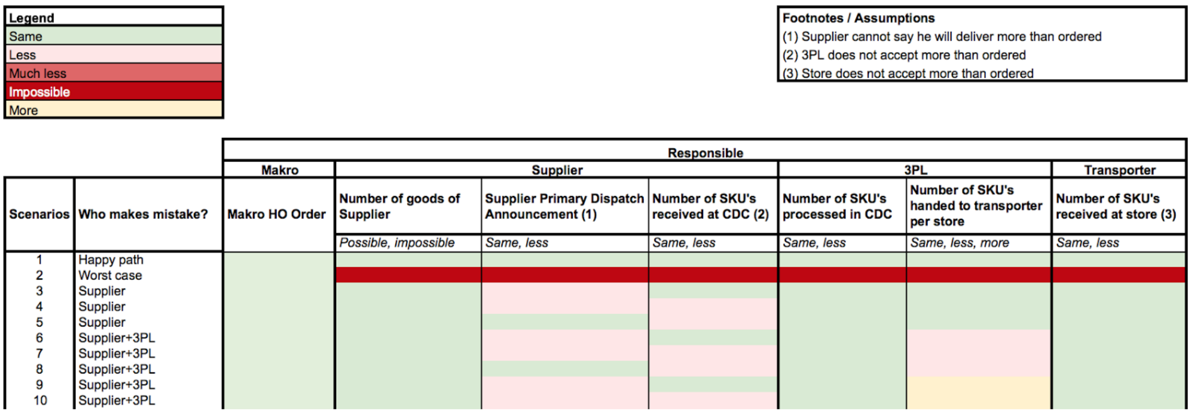

Figure 5.2: Scenario building of 49 different scenarios

Now that all different scenarios are known, it is important to consider what actions need to be taken by which actor when a certain error is discovered during the supply chain process. For every error a different set of actions exists. These sets of actions are combined with all unique scenarios into a schematic flowchart, which is to be found in appendix F.

An example of a small part of the flowchart is shown in Figure 5.3. This specific part explains the action plan that should be carried out when it turns out that the supplier delivered more or the same amount of SKU's compared to the amount of SKU's promised during the Primary Dispatch Announcement. After this action plan is completed, the path through the flowchart can be continued to the next source of error, where the next action plan is provided. By breaking down all the different mistakes per source of error, the flow chart covers all 49 existing scenarios.

This information can be used as input for the E2E testing to ensure the functioning of the integrated components in the entire system in all real-world scenarios.

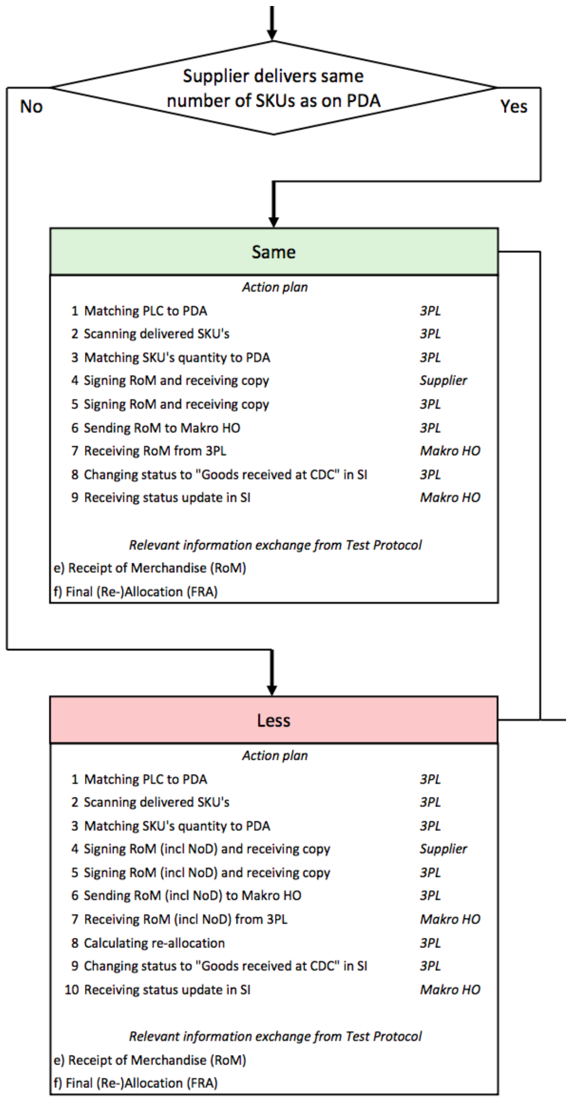

Figure 5.3: Example of part of flowchart for scenario testing

5.3 Gantt chart

To make sure that the implementation of the new design of information flows will run smoothly, it is necessary to formulate a planning according to which project implementation will be executed in which phase. Coordinating the deadlines between different departments within a business is an essential part of this implementation process. In this planning two important aspects need to be taken into account: the implementation of the cross-docking center and the implementation of the communication system Oracle. In order to do so the planning is developed in the format of a Gantt chart.

A Gantt chart is a type of chart in a spreadsheet that graphically depicts a project schedule; it shows the start and finish dates of project resources, milestones, tasks and dependencies (Business Dictionary, 2017). It allows for effective alignment of business resources across a time dimension.

Based on the responsible departments or persons, all activities in the Gantt chart are divided into five subjects: Cross Docking Bid Process, M40+ Package Releases, Implementation of Cross Docking, Integration of 3PL and Makro Systems and Phases of Implementations. The Gantt shows the duration and deadlines of all activities and shows key milestones, such as moments of going live with a system. Existing plannings and deadlines were combined, filtered and amplified until a complete Gantt chart existed. All this information was based on knowledge gained from interviews with the different departments.

One of the goals of the Gantt chart is to make sure that all faces of the different departments are facing the same direction. It is necessary for all departments to agree on the same planning, because they have to work together very closely. Furthermore, the board of Makro Colombia will use the Gantt for the overall company and project planning. According to the Gantt the final start of all operations will be on the 25th of June in 2018. A part of the Gantt is to be found in Figure 5.4.

Activity	Responsible	Starts	Ends	Duration (Working days)	April Week 14 02-apr	Week 15 09-apr	Week 16 16-apr	Week 17 23-apr	Week 18 30-apr	May Week 19 07-mei	Week 20 14-mei	We 21
Implementation of Cross Docking												
Definition of warehouse location	3PL	4-dec	29-dec	20								
Building of rack system and setting up offices	3PL	1-jan	26-jan	20								
Creation of WMS interfaces (1)	3PL & Makro	1-jan	9-feb	30								
Internal tests of WMS system	3PL	12-feb	9-mrt	20								
Small group of suppliers (4%) involved in testing	3PL, Makro & Suppliers	12-mrt	22-jun	75								
Testing with Makro (2)	3PL, Makro	12-mrt	13-apr	25								
Integration of 3PL and Makro systems												
Preparation (1)	Makro, 3PL	1-jan	19-jan	15								
Smoke test and build (1)	Makro, 3PL	1-jan	9-feb	30								
Training (starting after training package 3)	Makro, 3PL	30-apr	22-jun	40								
System integration tests (2)	Makro, 3PL	12-mrt	13-apr	5 Weeks								
Purchase Order testing	Makro, 3PL	12-mrt	15-mrt	4								
Proof of Order testing	Makro, 3PL	16-mrt	21-mrt	4								
Primary Dispatch Announcement testing	Makro, 3PL	22-mrt	27-mrt	4								
(Primary (Re-)Allocation testing)**	Makro, 3PL	28-mrt	2-apr	4								
Receipt of Merchandise testing	Makro, 3PL	3-apr	6-apr	4								
Secondary Dispatch Announcement testing	Makro, 3PL	9-apr	13-apr	5								
Final tests and execution	Makro, 3PL	16-apr	22-jun	10 Weeks								
End-to-end testing	Makro, 3PL	16-apr	4-mei	15								
Performance testing	Makro, 3PL	7-mei	18-mei	10								
User acceptance testing	Makro, 3PL	21-mei	8-jun	15								
Execution	Makro, 3PL	11-jun	22-jun	10								
Phases of implementation												
START OF OPERATIONS	Makro, 3PL	25-jun	25-jun	0								
4% of suppliers operating through CDC	Makro, 3PL	Jun-2018	Jul-2018	20								
8% of suppliers operating through CDC	Makro, 3PL	Jul-2018	Aug-2018	20								
20% of suppliers operating through CDC	Makro, 3PL	Aug-2018	Sep-2018	20								
25% of suppliers operating through CDC	Makro, 3PL	Sep-2018	Oct-2018	20								
30% of suppliers operating through CDC	Makro, 3PL	Oct-2018	Nov-2018	20								
35% of suppliers operating through CDC	Makro, 3PL	Nov-2018	Dec-2018	20								

Figure 5.4: Example of Gantt chart

6. Conclusion

The implementation of a cross-docking center and the subsequent restructuring of Makro's physical and digital supply chain network, is an incredibly large and complex undertaking. Furthermore, analyzing the projected effects of this restructuring to identify key boundary conditions for the cross-docking center proved to be a multi-faceted problem on different levels of aggregation. Integrally changing the design of Makro's supply chain means rethinking key processes and identifying crucial communication nodes. In the following section, the main findings of each of the three research questions will be discussed so as to understand how Makro's supply chain can best be streamlined.

Designing Makro's future flow of information

This investigation has attempted to devise an overall architecture for Makro's new flows of information whilst building upon existing practices identified on the work floors in stores, but also in the various departments at head office. Makro's future flow of information will be controlled through a far more centralized system of modules connected through Oracle Retail. Each of these modules is to be run by separate departments, and much information between these modules is automatically exchanged between relevant parties.

A retail management system will coordinate the placement of orders, whereupon Makro's old software, MBS, will solely be the server platform through which orders are placed via EDI at the relevant suppliers. The 3PL's warehouse management system will then control and process the ordered SKU's whereupon they are shipped through to the allocated stores, which monitor their stock levels in MBS. The designed Flow of information chart (Appendix B) and Swimlane document (Appendix D) show precisely what type of information is communicated between Makro head office, its stores, the suppliers, the 3PL and the transporter at each phase along the supply chain. For optimal replenishment and an effective supply chain, it is imperative that the interfaces between Oracle, WMS, MBS and the suppliers' software meets all conditions stipulated in these documents.

Testing and implementing information flows with the cross-docking center

Testing the functionality of designed information flows across the relevant modules of associated actors is a pivotal procedure before a successful implementation. By testing the created interfaces, Makro and the related suppliers, 3PL and transporters ensure that no preventable financial losses are made upon the definite deployment of the cross-docking center. A software or interface error upon deployment could potentially lead to undesired stock levels would consequently translate to less sales and less income for Makro.

This investigation sets the boundary conditions for proper system tests, by explicitly naming all parameters and scenarios needed for the System Integration Test (Appendix E) and the End-to-End Tests (Appendix F) respectively. A total of 20 unique key input data sets were identified which encompass all information flows to and from the Warehouse Management System. Furthermore, 49 different scenario's were identified across the entire supply chain process through which the number of SKU's finally received at a Makro store may differ from the Purchase Order placed by Makro. A flowchart in which these two testing procedures are integrated and compiled serves as a visual aid to the managers who responsible for test deployment and provide an easy and comprehensible guide to understanding Makro's complex end-to-end supply chain process. This step-by-step testing procedure, in combination with the Gantt chart (Appendix G), is paramount to identifying bottlenecks in the newly designed interfaces between the 3PL and Makro, and is a practical tool tailor-made for this dynamic and highly responsive field.

Boundary conditions for deployment of a cross-docking center

In negotiations with the 3PL, it is crucial for Makro to know how many loading docks and parking spaces are needed at the CDC when the CDC is fully operational. A future delivery analysis was conducted in order to know the future frequency of trucks arriving and departing at the CDC. The investigation also analysed the benefits of a CDC comparing two future scenarios. Due to the fact that suppliers can deliver several orders from several Makro stores in one truck to the CDC and the 3PL delivers large (full) trucks to each individual store, the total deliveries with a CDC in 2021 will be 80% less than in a future situation without a CDC.

In 2021, it is possible that 57% of the total volume can be transported via the CDC. Using the queueing theory, requirements have been formulated for the construction of the CDC and the area around it. Calculations based on the expected number and volume of future deliveries have shown that the CDC requires 6 unloading docks at the inbound side, with an average of 4 docks being operational, and 5 loading docks at the outbound side, with an average of 3 docks being operational. The parking space at the CDC is required to provide room to at least 9 trucks at the inbound side of the CDC and at least 7 trucks at the outbound side. Lastly, this investigation has shown that in the future situation with CDC, 8 unloading docks at the Makro Cumará store is more than sufficient. Having 2 docks operational gives sufficient capacity and parking space seems not be necessary.

Broader implications for the supply chain industry

Although the proposed procedures are specific for the case of Makro, several tools used and developed in this study are applicable to the larger field of supply chain optimization.

The Swimlane framework is an outstanding tool to differentiate roles and responsibilities between actors. Furthermore, the overall constructed structure of four separate phases during which processes shift from a retailer, to suppliers, to a 3PL, to transporters, and back to the retailer is applicable in the supply chains for almost all different industries.

Similarly, the end-to-end flow chart with identified scenarios and step-by-step interface testing procedures to accommodate for differences in SKU levels provides a framework for supply chain experts to test the state of communication infrastructure.

7. Discussion

7.1 Recommendations

In response to all deliverables and conclusions described in this report several recommendations towards Makro Colombia can be made. These recommendations should help Makro to deal with the current problems as described in paragraph 1.2. The recommendations are divided into five different categories: flows of information, interface, direct assistance, logistical process, and planning.

Flows of information:
First of all it is recommended to implement the Preliminary Re-Allocation in the long-term. This would improve the accurate demand forecasting and up-to-date replenishment.
Secondly, the Notice of Difference should be merged with the Receipt of Merchandise, so that only one document needs to be signed. This would improve the efficiency of this part of the supply chain.

Interface:
It is recommended that a status interface will be implemented that tracks PO's in all phases. This status interface should provide live insight to Makro HO and 3PL about PO statuses, which would improve the transparency and therefore the efficiency of the supply chain.
Furthermore, the status interface as described above should be able to show five different statuses: 1) Booking awaited at CDC, 2) Delivery cancelled by supplier, 3) Delivery booked at CDC, 4) Goods received at CDC, 5) Goods loaded in truck. These statuses cover all crucial phases of the supply chain processes.

Direct assistance:
In case of any problems, some form of direct and personal assistance is recommended. It is preferred to always have a Makro employee available at Makro Head Office for questions over the phone. Also, a 3PL employee should be available at CDC for the same reason.
Furthermore, it is recommended to double these amount of employees (available for questions over the phone) during the starting phase of the CDC.

Logistical process:
Concerning the logistical processes of the supply chain of Makro Colombia, there is one small recommendation. After a positive seal check at the stores, an extra (random) quality check is not necessary. In case of a positive seal check, it can be assumed that all SKU's within the package are still intact after the transport from the CDC to the stores. This will save time.

Planning:
The period from mid-February until early May will require the most allocation of Makro resources for the integration of interfaces and the implementation of the CDC. Therefore, it is recommended to anticipate on this period in advance.

The last recommendation concerns all different departments and might even be the most important one. In order to complete this project successfully, absolute alignment of resources and interests of all actors is key. During the research it was noticed multiple times that a lot of uncertainties existed between different departments about project responsibilities, activities and planning. Uncertainties often lead to misunderstandings which complicate the progress of the project. Therefore, it is highly recommended to make sure that all involved actors communicate well and on a frequent basis, in order to face the same direction.

7.2 Limitations

During the research there were some limitations that might have had influence on the results. Since this reduces the reliability of the project, it is important for Makro Colombia to critically take these limitations into account when processing the recommendations as described above.

Unknown 3PL
A first important limitation concerns the 3PL, which is still unknown. Therefore, some assumptions were done within this research about the preferences and abilities of the 3PL. After finishing the negotiations with the 3PL it will turn out whether these assumptions were true or false and in what way this influenced the final results.

Release 3
The focus of this research was on Release 3, while Release 4 was already being developed. This was a limitation for the project, because it restricted the amount of possible solutions and it often led to inconsequent decisions. Also, because the results are based on Release 3, the recommendations will only be useful during the short period between Release 3 and Release 4.

Supplier knowledge
During this research there was only limited knowledge available about suppliers in general and about their individual preference in specific. Just like with the 3PL, a lot of assumptions had to be done, which could have influenced the final results.

Testing knowledge
Also, there was limited knowledge about testing procedures and times. Only two Makro employees were available for consult about this kind of information, which resulted in too little knowledge about this specific subject. Therefore, some assumptions were done in this category as well.

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