National Technical University of Athens
School of Mechanical Engineering
Section of Industrial Management and Operational Research

"A Proposed Framework for Supply Chain Process Improvement in the Retail Sector with the Contribution of Lean Six Sigma"

Konstantinos E. Stergiou
Mechanical and Aeronautical Engineer, University of Patras

Supervisor: Nikolaos A. Panayiotou
Professor NTUA

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Examination Committee:

Dr. Panayiotou N., Supervisor
Professor, NTUA

Dr. Tatsiopoulos I.
Professor, NTUA

Dr. Ponis S.
Professor, NTUA

Dr. Mentzas G.
Professor, NTUA

Dr. Psarras J.
Professor, NTUA

Dr. Adamides E.
Associate Professor, University of Patras

Dr. Karacapilidis N.
Professor, University of Patras

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Table of Contents

Table of Figures

Table of Tables

List of Abbreviations

ABSRM	Agent-Based System Reference Model
AI	Artificial Intelligence
ANOVA	Analysis of Variances
AR	Augmented Reality
ARCH	Autoregressive Conditional Heteroskedasticity
ARIMA	Autoregressive Integrated Moving Average
ARIS	Architecture for Integrated Information Systems
BCR	Benefit-Cost Ratio
BPI	Business Process Improvement
BPMN	Business Process Model and Notation
BPR	Business Process Reengineering
CBA	Cost-Benefit Analysis
CI	Continuous Improvement
CPFR	Collaborative Forecasting, Planning and Replenishment
CRM	Customer Relationship Management
CSF	Critical Success Factor
CTQ	Critical-to-Quality
CVRTW	Capacitated Vehicle Routing Problem with Time Windows
DC	Distribution Center
DFLSS	Design for Lean Six Sigma
DMADV	Define, Measure. Analyze, Design, Verify
DMAIC	Define, Measure, Analyze, Improve, Control
DMS	Distribution Management System
DOE	Design of Experiments
DPMO	Defects Per Million Opportunities
DPU	Defects per Unit
EPC	Event-driven Process Chain
ERP	Enterprise Resource Planning
FAD	Function Allocation Diagram
FMEA	Failure Mode and Effect Analysis
FTY	First Time Yield
GBDT	Gradient Boosting Decision Trees
GIS	Geographical Information System
GSCF	Global Supply Chain Form
IoT	Internet of Things
IRR	Internal Rate of Return
IS	Information System
JIT	Just in Time
KNN	K-Nearest Neighbors Regression
KPI	Key Performance Indicator
KSD	Knowledge Structure Diagram
LSL	Lower Specification Limit
LSS	Lean Six Sigma

LSS RSCPR	Lean Six Sigma Retail Supply Chain Process Reference Model
M2M	Machine-to-Machine
MAD	Mean Absolute Deviation
MAPE	Mean Absolute Percentage Error
ML	Machine Learning
MRP	Materials Resource Planning
MSS	Minimum Sample Size
NPV	Net Present Value
OTB	Open-to-Buy
PCF	Process Classification Framework
PO	Purchase Order
RF	Radio Frequency
RFID	Radio Frequency Identification
SARIMA	Seasonal Autoregressive Integrated Moving Average
SC	Supply Chain
SCM	Supply Chain Management
SCOR	Supply Chain Operation Reference
SD	Standard Deviation
SIPOC	Supplier, Input, Process, Output, Customer
SKU	Stock Keeping Unit
SME	Small and Medium-Sized Enterprises
SVR	Support Vector Regression
TAT	Turnaround Time
TPS	Toyota Production System
USL	Upper Specification Limit
VACD	Value Added-Chain Diagram
VMI	Vendor-Managed Inventory
VOC	Voice of Customer
VRB	Vehicle Routing Problem with Back-hauling
VRMT	Vehicle Routing Problem with Multiple Trips
VRTW	Vehicle Routing Problem with Time Windows
VSM	Value Stream map
WMS	Warehouse Management System

PREFACE

This dissertation deals with the improvement of retail supply chain processes, through the implementation of Lean Six Sigma (LSS), a Continuous Improvement (CI) methodology which continuously gains ground as a process improvement and operational excellence approach. After the review of the literature and the detection of the gap regarding the implementation of LSS in the retail supply chain, this study tries to fill this exact gap by proposing improvement actions for specific activities of the processes of retail supply chain, implemented by following the phases of the DMAIC (Define-Measure-Analyze-Improve-Control) method and utilizing specific LSS tools, in the form of a reference model, which aims at the adoption of managerial changes and technological solutions according to the world's best practices presented in the literature right now. The data and the information for the development of the reference model, regarding the supply chain processes and operations, were drawn from the research that was conducted in two major retailers in Greece. One of the two companies also participated in a case study in which the implementation of the model was tested in a selected supply chain process, utilizing a specific LSS initiative (improvement action) for the improvement of concrete activities.

ΕΠΟΨΗ

Η διατριβή αυτή πραγματεύεται τη βελτίωση των διαδικασιών της εφοδιαστικής αλυσίδας εταιρειών που ανήκουν στον κλάδο του λιανικού εμπορίου, με τη χρήση της μεθοδολογίας του Λιτού Έξι Σίγμα (LSS), η οποία βασίζεται **στις** αρχές της συνεχούς βελτίωσης και κερδίζει συνεχώς έδαφος σαν μια προσέγγιση βελτίωσης των επιχειρησιακών διαδικασιών και της επίτευξης της επιχειρησιακής αριστείας. Η ανασκόπηση της βιβλιογραφίας οδήγησε στον εντοπισμό ενός κενού, όσον αφορά την εφαρμογή του LSS στην εφοδιαστική αλυσίδα των επιχειρήσεων του λιανικού εμπορίου, το οποίο η παρούσα μελέτη προσπαθεί να καλύψει, αναπτύσσοντας ένα μοντέλο αναφοράς που προτείνει δράσεις βελτίωσης για συγκεκριμένες δραστηριότητες των διαδικασιών της εφοδιαστικής αλυσίδας του λιανικού εμπορίου, ακολουθώντας τη μέθοδο της DMAIC (Define-Measure-Analyze-Improve-Control) και χρησιμοποιώντας τα κατάλληλα εργαλεία LSS που τελικά οδηγούν σε οργανωτικές αλλαγές και στην υιοθέτηση σύγχρονων τεχνολογικών λύσεων, σύμφωνα με τις βέλτιστες πρακτικές που παρουσιάζονται στη βιβλιογραφία. Για τη συλλογή των δεδομένων και των πληροφοριών που χρησιμοποιήθηκαν για τη διαμόρφωση του μοντέλου πραγματοποιήθηκε εκτενής μελέτη των διαδικασιών και της λειτουργίας των εφοδιαστικών αλυσίδων **σε** δύο από τις μεγαλύτερες εταιρείες λιανικού εμπορίου στην Ελλάδα. Η μία από τις δύο εταιρείες, στη συνέχεια, συμμετείχε στην πρακτική εφαρμογή του μοντέλου. Κατά συνέπεια, μέσω της μελέτης περίπτωσης, το μοντέλο δοκιμάστηκε στη βελτίωση συγκεκριμένων δραστηριοτήτων μιας επιλεγμένης διαδικασίας, με βάση μια προτεινόμενη πρωτοβουλία LSS (δράση βελτίωσης).

1 Introduction

The continuous search for the competitive advantage is a crucial issue for every company operating in any sector. Nowadays, the pace of the changes that take place in the business environment is extremely high and organizations of all sectors should follow the trends and the best practices for the assurance of their success. The development of advanced technological solutions and the fourth industrial revolution (Industry 4.0) play a determinant role for these radical changes in the way that companies operate. The automations that can be inserted in every aspect of operations help the companies in their continuous striving for cost reduction and improved efficiency and productivity. In this way, organizations can cope with the constantly increasing requirements of their customers who demand a wide variety of products at low prices, with high quality and functionality. In addition to the factor of the demanding customers, the globalization of the economy, and the development of stable global supply chains lead the organizations to the confrontation of competitors of the global business environment. For this reason, a company should follow the global standards for its operations in order to retain its sustainability.

All this puts pressure on organizations that search for solutions in order to maintain their profitability. The need for change in their structure, so to manage to be competitive, leads to a radical change in their culture and mentality, which now have to force the open cooperation between the different layers and departments of the companies. Business processes play the crucial role for the achievement of this structure and mentality change. The need to detect the problems and strengths, as well as the adjustment of their processes, for the redetermination of the operational and strategic goals, results in the adoption of business process improvement methodologies.

A “process” is a collection of activities, which gets a set of input and raises a set of outputs (Temponi, 2006; Wu, 2003). The aim of a business process is to create value for the customers via its outputs. Business processes usually need to be changed and improved in order to achieve a better result. For this reason, the scientific area of Business Process Improvement (BPI) emerged, leading to business processes examination and redesign to achieve cost efficiency and service effectiveness improvement (Lindsay et al., 2003; Vidovic and Vuhic, 2003). The next step of BPI was the gradual development of a framework aiming to achieve improvements in business processes in a constant and continuous manner, creating Continuous Improvement (CI) rationale.

CI contributes to quality increase, operational excellence, and performance enhancement (Thomas et al., 2009; Assarlind et al., 2012), as well as waste and product variation reduction (Kalashnikov et al., 2017) in the processes of an organization. The notion of CI has gained ground over the last decade among the majority of organizations in all sectors, as they benefit from its nature, which, through gradual steps and a series of improvement projects, can lead to cumulatively significant results regarding the investment margin of each company. A common methodology that is used for the achievement of CI is Lean Six Sigma (LSS). The concept of CI, implemented via the LSS approach, has become popular over the past decade (Panayiotou and Stergiou, 2021, Patel and Patel, 2021, Singh and Rathi, 2019). The LSS methodology is a way of faster implementation of CI in an organization (Albliwi et al., 2015). LSS target is the exploitation of both the lean concept and the six sigma methodology benefits (Anthony and Antony, 2016). According to Snee (2010), it is “a business strategy and methodology that increases process performance resulting in enhanced customer satisfaction and improved bottom line results.”

LSS is continuously gaining ground as a methodology of process improvement, for various reasons which are inherent in the nature of the concept. The most important thing is that it examines the processes from the customer's perspective. It recognizes the needs of customer and tries to add value and increase the quality of products or services that are offered to the customers, achieving at the same time the reduction of unnecessary waste and costs. In addition, the structured and straightforward methods that are offered by LSS for the definition and the analysis of the problems, along with a variety of tools that offer a quantitative view of the problems and can be adapted in any case, help the organizations take the necessary improvement actions, based on raw data.

On the other hand, the LSS framework has been criticized based on misconceptions, such as LSS means layoffs, LSS can be applied only in the manufacturing sector or within specific environments, LSS is pushed by consultants and is a quality-only program (Arnheiter and Maleyeff, 2005). However, the literature shows that LSS methodology is the most widely used CI strategy globally (Arcidiacono et al., 2016; Gupta et al., 2018) and in several sectors (Panayiotou and Stergiou, 2021; Alhuraish et al., 2017). Especially over the last years, the LSS methodology has been extended to healthcare, education, governmental services, and even police (Rodgers et al., 2021) with the intention to achieve the benefits that have been proved to be attained in the other sectors. Moreover, the correct and efficient implementation of LSS requires the development and maintenance of a CI mentality and of a team spirit embracing the philosophy of CI within the company, which means that external consultants are not enough to achieve the desired level of benefits for the company, but internal company environment is the one that is responsible for the support of the CI efforts.

Although LSS is a very famous methodology for process improvement, the analysis of literature revealed that even if there is a high penetration of this methodology in both manufacturing and services sector, there are sectors in which there are very few studies even though they can be favoured by tangible benefits, such as the retail sector (Panayiotou and Stergiou, 2021; Singh and Rathi, 2019). The literature recognizes the contribution of LSS initiatives to the supply chain processes of retail companies, by identifying significant benefits, such as substantial cost reduction and improved inventory management and replenishment models (Martin, 2014; Madhani, 2020a, 2021). However, only a few studies have been conducted for the implementation of LSS in the retail sector (Lameijer et al., 2016; Singh and Rathi, 2019; Panayiotou and Stergiou, 2021). The benefits that LSS can bring to the retail sector become more significant when considering that retail employees account for 10 to 15 percent of the job market worldwide (IFC, 2020). The importance of the retail sector in the global economy is indicated by two additional figures. The first is that the sector has grown about five percent from 2013 to 2018 (Deloitte, 2020) and the second is that the contribution of the retail sector in US GDP was around six percent (BEA, 2019). These facts reveal the significance of the retail sector in the world economy and society, and indicate the need for improvement initiatives in the sector in order to ensure the consistency of its operations efficiency. Hence, research on the reasons that act as barriers in the adoption of LSS in the supply chain of the retail sector was conducted in order to fully investigate why there is low penetration of LSS in such a crucial sector. The literature revealed eight barriers of LSS implementation in the retail supply chain, all of which are presented in the dissertation; the most important ones are the lack of LSS knowledge (Albliwi et al., 2014) and resistance to change (Oreg and Berson, 2009; Shokri et al., 2014; Zhang et al., 2016), the existence of problems in information sharing and flow within processes and stakeholders (Hussain et al., 2019; Jadhav et al., 2014), (Jadhav et al., 2014), the non-existence of tools and the lack of the full view of processes in order to improve them to respond to market pressures, the lack of planning in the organizational level, and technological barriers (Dahlgaard & Mi Dahlgaard-Park, 2006; Snee, 2010). Thus, the recognition of this gap in the literature and the barriers of LSS implementation in the retail supply chain were the key motivation of the research of this doctoral dissertation, which presents the development of a reference model for the guidance of the implementation of LSS and specific improvement actions (LSS initiatives) in the supply chain of the retail sector, aiming at management and technological changes.

The LSS RSCPR (Lean Six Sigma Retail Supply Chain Process Reference Model) consists of modeled business processes of the supply chain of retail sector and proposes improvements in these processes following the principles of LSS and utilizing LSS tools. This model manages to combine the notion of CI and LSS with the specific characteristics of the retail supply chain, utilizing the DMAIC (Define, Measure, Analyze Improve, Control) method designed to lead to the adoption of best management and technological practices, as shown in **Figure 1.1**.

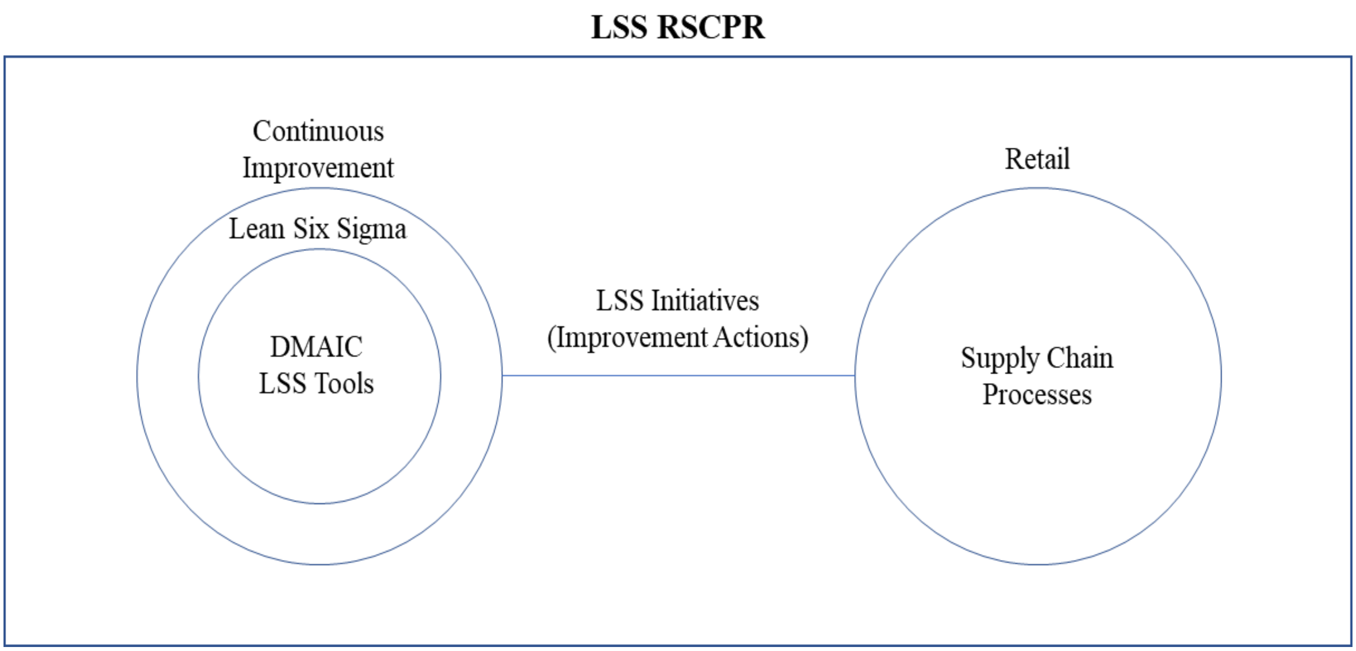


Figure 1.1. LSS RSCPR context

The aim of the configuration of the LSS RSCPR is its practical implementation in the real conditions of retail companies. The requirements and needs of each company change the manner in which the reference model can be applied. An operational researcher must test his/her model in the real business world in order to find out their usefulness and their applicability. The real testing of a proposed framework occurs in the settlement of daily problems that a company and its employees, with whom the researcher should harmoniously cooperate, confront. Thus, the examination of a new model through case studies is the only way to understand its implementation, by facing at the same time the difficulty of an organization to change its operation. This model tries to make LSS accessible and known to the retail sector and to offer a structured solution that will make the improvements and changes more comprehensible to management teams. The modeling of the supply chain processes also gives an instant overview of the operations to the management team and the proposal of specific technological solutions, via LSS initiatives, by the model for the gradual adoption of the simpler ones to the more complex ones of them could lead to the demolition of technological barriers as the knowledge and infrastructure of technological applications will grow.

This doctoral dissertation is structured in five Chapters in order to present the notions of this research, the configuration and the testing of the LSS RSCPR, and the extracted inferences. Specifically, ***Chapter 2*** presents the theoretical background of the research, explaining the notions of CI and LSS methodology along with its methods and tools, and the notion of supply chain in retail. In addition, a literature review of the benefits, critical success factors and the adoption of LSS in supply chain is conducted along with a review of the models that have been proposed in the literature as references/frameworks, with or without LSS, for the supply chain. This Chapter continues with the recognition of the research gap that acted as a trigger for the development of the proposed reference model and ends with a review of the contemporary technological solutions utilized in the retail supply chain in order to identify which of them can be incorporated in the LSS RSCPR. ***Chapter 3*** presents the research methodology that is followed in this study for the development of the reference model by firstly analyzing the notions of research design, research paradigms, research strategy, research purposes and research quality.

In ***Chapter 4*** the LSS RSCPR is presented, in detail, beginning from the depiction of the models and its relations, and the rationale behind the development of the model. Then, the modeled supply chain processes are presented striving to cover the full spectrum of the supply chain, and ultimately, the proposed LSS initiatives, combined with the activities of the modeled processes, are presented based on the modeled processes and the global best practices of the retail supply chain. Subsequently, the testing of the LSS RSCPR is conducted in ***Chapter 5*** through a case study in a major retailer which participated in the development of the model. The methodology of the case study follows the DMAIC method, as proposed by the model, in combination with the suggested case study methodology by Yin (2003, 2009).

Finally, the theoretical and managerial conclusions/implications of this dissertation, along with suggestions for further research, are presented in ***Chapter 6***.

2 Theoretical Background and Literature Review

2.1 Theoretical Background

2.1.1 Definition of Lean Six Sigma

The mentality of CI contributes to quality increase, operational excellence and performance enhancement (Thomas et al., 2009; Assarlind et al., 2012), as well as waste and product variation reduction (Kalashnikov et al., 2017) in the processes of an organization. That is why, the concept of CI, implemented via LSS approach has become popular over the past decade (Panayiotou and Stergiou, 2021, Patel and Patel, 2021, Singh and Rathi, 2019). The LSS methodology is a way of faster implementation of CI in an organization (Albliwi et al., 2015).

Lean is a "dynamic process of change, driven by a set of principles and best practices aimed at continuous improvement" (Womack et al., 1990). Lean principles were initially adopted in Japan by Toyota (Toyota Production System-TPS) in the 1940s after the Second World War by Taiichi Ohno (Womack et al., 1990; Womack and Jones, 2003; Maleyeff et al., 2012), while subsequently, the approach of lean thinking evolved into a holistic business strategy aiming at CI (kaizen) (Abreu-Ledon et al., 2018). Eiji Toyoda and Ohno, due to post-World War II constraints and after reviewing Henry Ford's mass production approach, decided to build an independent approach after realizing that mass production would not work in Japan (Tohidi and KhedriLiraviasl, 2012). Ohno and Shingo created the Toyota Production System (TPS) with the fundamental goal of thoroughly reducing non-value-added wastes, thus increasing production efficiency. According to Ohno, a firm's primary goal should be to eliminate waste (Ohno, 1988). The TPS was developed with the goal of eliminating Muda (waste), Mura (unevenness), and Muri (overburden) (Liker, 2004) [Muda, Mura and Muri - Japanese words]. Jidoka (automation of activities) and just-in-time (JIT) are the two pillars of the house of TPS (Liker and Convis, 2011). Overproduction, waiting, transportation, processing itself, inventory, movement, and producing defective parts were all identified as waste by Ohno (1988). TPS received no global attention until the oil crisis of the 1970s. Nevertheless, as part of the International Motor Vehicle Program, researchers at Massachusetts Institute of Technology examined the manufacturing practices at the assembly level in automobile manufacturing companies, including the Toyota Production System (Bhasin and Burcher, 2006). Krafcik (1988) was the first to coin the term 'lean' in his article "Triumph of the lean production system," which was based mostly on the study of Toyota Production System. Though the TPS captured the interest of the world, it was made famous as "lean manufacturing" or "lean production" through the book entitled "The Machine that Changed the World" by Womack et al. (1990). The five key principles of lean philosophy (shown in **Figure 2.4**) were described by Womack and Jones (1996) as:

1. "Value" from the perspective of the customer: Value is always determined by the customer's needs for a certain product. What is, for instance, the manufacturing and delivery timeline? What is the price point? What are other significant requirements or expectations that must be fulfilled? This information is critical for defining value.
2. Identification of "value stream": As soon as the value (end goal) has been identified, the next step is mapping the "value stream"**;** that is, all the steps and processes involved in taking a certain product from raw materials and delivering the final product to the customer. Value-stream mapping is a straightforward but eye-opening practice that identifies all of the actions that move a product or service through a process. That process can be in design, procurement, production, administration, HR, delivery, or customer service. The idea is to draw a "map" of the material/product flow through the process, on one page. The objective is to identify every step that does not add value and then to look for ways to erase those wasteful steps. Value-stream

mapping is often cited as process re-engineering. Eventually, this exercise also leads to a better understanding of the overall business operation.

3. Make it "flow": Once the waste has been eliminated from the value stream, the next step is to make sure the rest of the steps run smoothly with no interruptions, delays, or bottlenecks. As LEI advises, "make the value-creating steps occur in tight sequence so that the product or service will flow smoothly toward the customer". This may entail breaking down silo mentality and attempting to become cross-functional across all departments, which can be one of the most challenging obstacles for lean programs to overcome. Nonetheless, studies suggest that this will also result in significant gains in productivity and efficiency, often up to 50-percent improvement or more.
4. Establish the "pull": With enhanced flow, time to market (or time to customer) can be drastically improved. This makes it considerably easier to deliver products as needed, as in "just in time" manufacturing or delivery. This implies that the customer can "pull" the product from you as needed (often in weeks, instead of months). As a result, products don't need to be built ahead of time, and materials don't need to be stockpiled, resulting in expensive inventory that needs to be managed, thus saving money for both the manufacturer and the customer.
5. Striving for "perfection": Achieving Steps 1-4 is a good start, but the fifth step is likely the most crucial one: incorporating lean thinking and process improvement into your corporate culture. As gains continue to rise, keep in mind that lean **is** a dynamic system that requires ongoing effort and vigilance to master. Every employee should be part of the lean implementation process. A process is not truly lean until it has been through value-stream mapping at least half a dozen times, according to lean experts.

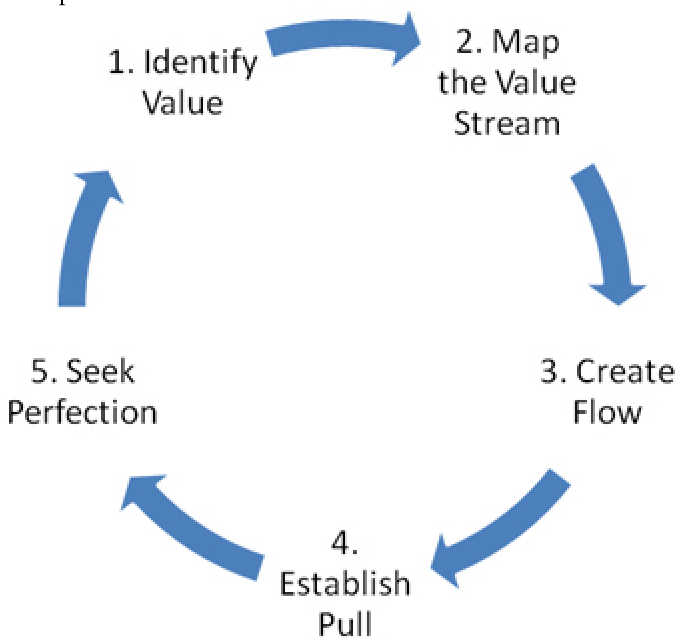


Figure 2.1. Five principles of lean (Source: Lean Enterprise Institute, 2016)

According to different researchers, Lean as a philosophy focuses on "eliminating the waste throughout the value stream" (Liker, 1997; Seth and Gupta, 2005; Shah and Ward, 2007), "reducing processing time and delivery time" (Liker, 1997; Negrão et al., 2017; Staats et al., 2011), "achieving highest product quality at the lowest cost" (Negrão et al., 2017; Reosekar, 2011), and "reducing or minimizing the production system wastes which result in better production system performance and increased value to the customer through higher customer satisfaction in terms of product or service quality and variety" (Thanki and Thakkar, 2011).

The main aim of lean is to eliminate non-value-added activities and waste in every type of industry (Womack and Jones, 2003; Naslund, 2008), as well as to reduce total cycle (Drohomeretski et al., 2013; Lee and Wei, 2009) and lead time (Hu et al., 2008; Chen et al., 2010). It provides organizations with the opportunity of a wider variety of products or services offering at a lower cost and highest quality, using fewer resources than traditional operating approaches (Marodin et al., 2018).

Six Sigma is a generic and versatile methodology (de Mast and Lokkerbol, 2012) that can be defined as "a well-established approach that seeks to identify and eliminate defects, mistakes or failures in business processes or systems by focusing on those process performance characteristics that are of critical importance to customers" (Antony, 2008). Six sigma is a statistical methodology, which started from Motorola in the 1980s (Sin et al., 2015; Timans et al., 2012) and evolved into a competitive corporate strategy for plenty of organizations (Kumar et al., 2008), striving to achieve variation and deviation reduction in business processes (Chakravorty and Shah, 2012; Naslund, 2008). Motorola, a leading manufacturer of electronic products in the United States, recognized and accepted the existence of low-quality products, and decided to enhance product quality and achieve a tenfold increase in performance. Smith, in his report, discovered an interesting connection between poor product performance and defects in the form of rework during the manufacturing process (Process Quality Associates Inc, 1996). Smith and Harry became aware of the problem and worked to solve it. They proposed the concept of a "logic filter," which ultimately developed into a four-stage problem-solving approach: measure, analyze, improve, and control (MAIC) (Brady and Allen, 2006; Desai et al., 2012). This problem-solving approach became known as the Six Sigma program. Motorola saved more than $16 billion owing to Six Sigma programs (Brue, 2015). The company also received the inaugural Malcolm Baldrige National Quality Award (MBNQA) for its six-sigma program in 1988. (Bhote, 1989; Gowen et al., 2008). The Six Sigma program was later adopted by Honeywell and Allied Signal, General Electric, and other companies. Based on their experiences to improve clarity on the problem, General Electric introduced the Define ("D") stage to the four-stage problem-solving process, resulting in Define, Measure, Analyze, Improve, and Control (DMAIC), i.e. the Six Sigma methodology (Hoerl, 2001). In the 1990s, because of Welch's work at General Electric, the methodology was given more attention and was adopted extensively (Hahn et al., 2000). As a result, the Six Sigma approach evolved, with the primary goal of improving customer satisfaction by minimizing variability and/or defects. Sigma (the Greek letter 'σ') is a term used to describe the variation (distribution spread) about average (mean) for a set of data (Zare Mehrjerdi, 2011). Six Sigma is often cited as a methodology, a metric, and a management system. Sigma, as a metric, quantifies the measure of performance that specifies how well a process meets requirements. According to the Gaussian distribution, the data set within plus and minus three sigma limit covers 99.73% of the area covered under normal distribution, i.e. the probability of 2,700 data set (defectives) per million would fall outside three sigma limit assuming the process is centered, whereas in six sigma limit the probability is 0.002 defectives per million. In their Six Sigma program, Motorola considered a shift in the mean by plus and minus 1.5 sigma and arrived at 3.4 defectives per million opportunities (Emil et al., 2010). As a result, the statistical inference of the lower Sigma level in Six Sigma suggests that there is greater variation about the mean, whereas a higher Sigma level suggests less variation.

In **Table 2.1** the defects per million opportunities are presented in every sigma level taking under consideration the sigma shift. The sigma shift indicated that the long-term capability of the process cannot remain in a level of 6σ, but it will drop by 1.5σ (empirically calculated), to approximately 4.5σ. In **Figure 2.2** the statistical notion of six sigma is represented in the normal distribution curve (or bell curve). The simple meaning of this diagram is that improvements in the operation of a company should lead to the achievement of setting the limits of the variation (or deviation) of the process (or product) to be between -

6σ and +6σ from the mean, resulting to the yield of 99.9997% of products (or processes operation) without defects.

According to a few researchers, Six Sigma as a program aims "to the near elimination of defects from every product, process, and transaction" (Tomkins, 1997), "to accelerate improvement in product, process, and service quality by relentlessly focusing on reducing variation and eliminating waste" (Antony and Banuelas, 2002), "to reduce variation, which focuses on continuous and breakthrough improvements" (Andersson et al., 2006), and "to improve business performance, with an emphasis on the voice of the customer and using statistical analysis tools" (Zhan and Ding, 2016). According to Antony (2007) and Montgomery and Woodall (2008), there have been three generations of Six Sigma implementation since its inception. The first generation (1987–1994) aimed at reducing variation and defects in the manufacturing sector, while the second generation (1994–2000) aimed at improving business performance through cost reduction and improved product design, with an added focus creation of value, not only within an organization but also for its stakeholders, which is regarded as the third generation (2000 onwards). Furthermore, they cited Motorola, General Electric, Du Pont, Honeywell, Caterpillar, Posco, Samsung, and Bank of America as examples of first, second, and third generations of Six Sigma implementation.

In fact, the isolated deployment of Six Sigma is not able to remove all types of waste from the process and the isolated deployment of Lean cannot control the process in terms of statistics and eliminate variation (Corbett, 2011).

Table 2.1. Matching of sigma level with DPMO

Sigma Level	Sigma Level with 1.5σ shift	Defects per Million Opportunities (DPMO)	Yield (Percentage Inside Specifications)
1σ	-0.5σ	691,462	30.8538
2σ	0.5σ	308,538	69.1462
3σ	1.5σ	66,807	93.3193
4σ	2.5σ	6,210	99.3790
5σ	3.5	233	99.9767
6σ	4.5σ	3.4	99.9997

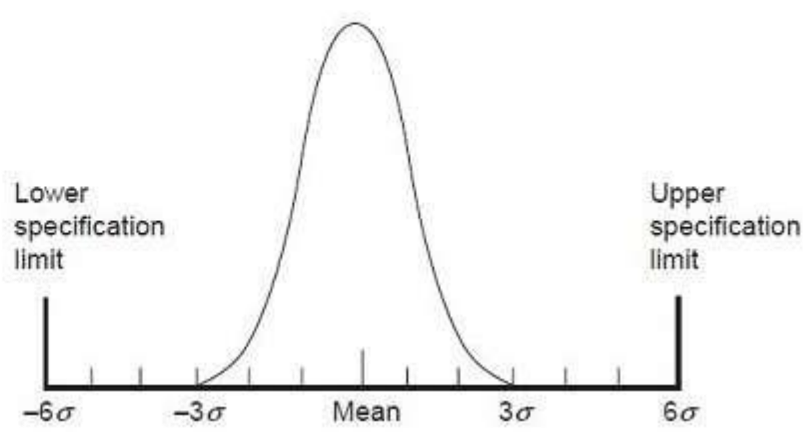


Figure 2.2. Statistical meaning of six sigma in normal distribution (Source: ASQ)

Lean Six Sigma (LSS) is an integrated framework resulting from combining lean and six sigma principles. The term was first introduced in the literature around 2000 (Albliwi et al., 2015). This framework's target is the exploitation of both the lean concept and the six sigma methodology benefits (Anthony and Antony, 2016). Snee (2010) stated that LSS is "a business strategy and methodology that increases process performance resulting in enhanced customer satisfaction and improved bottom line results." The LSS methodology aims to reduce production costs and enhance organization capability (Lee and Wei, 2009; Chen and Lyu, 2009) as well as to maximize the value for shareholders via quality improvement (Laureani and Antony, 2012). In **Table 2.2** various connotations of LSS are presented.

Table 2.2. LSS connotations

Furterer et al., 2005	"LSS is an approach focused on improving quality, reducing variation and eliminating waste in an organization"
Allen and Laure, 2006	"LSS is a recent approach to process improvement, combining the disciplines of Lean Manufacturing process improvement and Six-Sigma process improvement to gain the advantages of each discipline".
De Koning et al., 2008	"Lean Thinking and Six Sigma are considered as separate approaches available to process innovation, with complementary strengths. When combined as LSS, this approach provides a unified framework for systematically developing innovations"
Chen and Lyu, 2009	"LSS is considered as a powerful business strategy for employing a well-structured continuous improvement methodology to effectively reduce process variability and increase quality in business processes using statistical tools"
Andersson et al., 2009	"LSS frequently focuses on establishing and optimizing processes for activities that are repetitive in nature, as well as on driving out waste from the processes"
Niemeijer et al., 2010	"The Lean approach seeks to convert inputs to outputs for the customer with minimum waste. Six Sigma seeks to understand how the process outputs Y relate to inputs X".
	"LSS is a process-focused strategy and methodology for business improvement and can be used to improve processes, eliminate waste, reduce costs, and enhance patient satisfaction and safety"

Laureani and Antony, 2010	“LSS is a business improvement methodology that aims to maximize shareholders’ value by improving quality, speed, customer satisfaction and costs: it achieves this through merging tools and principles from both Lean and Six Sigma”
Lee et al., 2010	“Six Sigma is a well-structured methodology that focuses on reducing variation, measuring defects and improving the quality of products, processes and services. Lean Production is an approach that focuses on reducing the cycle time and eliminating waste in processes. Combining the principles of Six Sigma and Lean can achieve synergistic results that neither system can achieve alone”
Niu et al., 2010	“LSS aims to achieve total customer satisfaction and improved operational effectiveness and efficiency by removing waste and non-value added activities, decreasing defects, decreasing cycle time and increasing first pass yields, all resulting in a significant cost savings”
Atmaca and Girenes, 2011	“LSS emerges with the combination of Henry Ford’s Lean Manufacturing processes in the early 1960s and the Six Sigma generated by Motorola is the last evolution step in the manufacturing history. Both applications provide to achieve operational effectiveness. This means to apply changes, adding value, to process right at the first time and to act quickly and efficiently”
Vinodh et al., 2011	“LSS framework is scientifically designed with proper tools and techniques; proper training needs are to be provided to the team members; and quantifiable results need to be gained”
Johnstone et al., 2011	“LSS is a well-established methodology for improving the speed, quality and cost of manufacturing and service industries”
Manville et al., 2012	“LSS is an improvement-focused approach aimed at developing and improving operational capability, its implementation can also be considered strategic, in the sense of following an approach which deals with a particular business situation or circumstance.”
Maleyeff et al., 2012	“LSS is a system for improving the ways in which a business operates (both in its core business and within its supporting organization), LSS must be

	cognizant of the economic factors and external environment within which the organization competes”
Silva et al., 2012	“Six Sigma and Lean, acting together can become even more effective, as their strong points are able to cover the other’s gaps or deficiencies. This union may create a synergy, which exercises a great influence over the general performance of the business processes”
Cloete and Bester, 2012	“LSS represents a form of scientific method type, which is empirical, inductive and deductive, and system, which relies on data, and is fact-based”
Mousa, 2013	“LSS provides an over-arching improvement philosophy that incorporates powerful data-driven tools to solve problems and create rapid transformational improvement at lower cost”
Andersson et al., 2014	“Joint-use strategy of LSS offers a solution that creates more flexible, robust, and cost-efficient processes”
Raja Sreedharan et al., 2016	“LSS is one of the managerial practices for organisations to achieve operational excellence”
Laureani and Antony, 2016	Lean Six Sigma is a business improvement methodology that aims to maximise shareholder value by improving quality, speed, customer satisfaction and costs: it achieves this by merging tools and principles from both Lean and Six Sigma
Panayiotou and Stergiou, 2021	“Taking under consideration the theoretical orientation of LSS as well as the expected benefits, it can be concluded that it is appropriate for the majority of sectors, as it can help in substantial cost reduction and service quality improvement.”

All the definitions presented in Table are summarized by Burghall et al., (2014) identifying a ‘magnificent seven’ of LSS key principles:

1. Focus on the customer.

2. Identify and understand how the work gets done – the value stream.

3. Manage, improve and smooth the process flow.

4. Remove non-value-adding steps and waste.

5. Manage by fact and reduce variation.

6. Involve and equip the people in the process.

7. Undertake improvement activity in a systematic way.

In fact, the isolated deployment of Six Sigma is not able to remove all types of waste from the process and the isolated deployment of Lean cannot control the process in terms of statistics and eliminate variation (Corbett, 2011). The adaptability of LSS was the driving force for becoming the most popular CI business strategy in manufacturing and service sectors (Albliwi et al., 2015). LSS is also recognized as leading total quality management (TQM) tool for performance improvement in organizations with appropriate infrastructure that is built on leadership and change of culture (Shamsuzzamana et al., 2018; Vijaya Sunder et al., 2016; Shokri et al., 2016; Habidin et al., 2016; Dora and Gellynck, 2015; Assarlind et al., 2013; Wang and Chen, 2012; Choi et al., 2012; Hilton and Sohal, 2012; Atmaca and Girenes, 2013). It is considered as one of the most effective and disciplined top-down business transformation initiatives (Gijo et al., 2018; Antony et al., 2016; Knapp, 2015; Isa and Usmen, 2015; Bhat et al., 2014; Algasem et al., 2014; Biranvand and Khasseh, 2013).

The implementation of LSS also requires the appropriate expertise from the project team for the correct following of the methodology steps and the analysis of the data. There are four levels of (certified) experts in LSS methodology, as presented in **Table 2.3**, the White Belt, the Green Belt, the Black Belt, and the Master Black Belt.

Table 2.3. LSS belts

Title	Role in a LSS project
White Belt	*White Belt indicates a basic knowledge of the LSS philosophy and fundamentals and has no active part in an LSS project*
Yellow Belt	*The Yellow belt certification indicates knowledge of LSS application on projects, the specifics and how is applied. They are part of the project team and their role is to review the process improvements*
Green Belt	*The Green Belt certification indicates deep knowledge of LSS and the tools. They perform the data collection and the analysis, the lead the project alongside the Black belts and they support them*
Black Belt	*The Black Belt certification indicates of LSS methods. The Black belts are the project managers, they lead all the projects, they train, and they coach the members of the team. Usually, they are members of the company*
Master Black Belt	*The Master Black Belt is the mentor of the Black Belts and the Green Belts. To be considered (there is no certification) as a Master Black Belt years of experience as a Black Belt is required*

The two most recognized LSS methods are DMAIC (Define, Measure, Analyze, Improve, Control) which is the most characteristic method of LSS implementation in organization processes (coming from Six Sigma methodology), and DMADV (Define, Measure, Analyze, Design, Verify) or DFLSS (Design for LSS), which started from General Electric (Mo Yang et al., 2007) and aims to replace existing systems with new processes (Albiliwi et al., 2017). Both of these methods use the same qualitative or quantitative tools in every phase for a successful LSS implementation in business processes.

2.1.2 DMAIC and LSS Tools

2.1.2.1 DMAIC

The DMAIC method (**Figure 2.6**) is the most characteristic one, concerning LSS implementation in organization processes. It can be used in all sectors owing to its not standardized procedure (Psychogios and Tsironis, 2012). The adaptability of LSS was the driving force to become the most popular business strategy for deploying CI in all sectors (Albliwi et al., 2015). DMAIC is applied with a mix of appropriate tools from the Lean toolkit and Six Sigma at each step (Kumar et al., 2006; Vinodh et al., 2011). DMAIC project stages in a generic form, as described by De Koning and De Mast (2006), are:

1) ***Define***: Problem selection and benefit analysis. Definition of the CTQ (Critical to Quality) or CTQs (critical to quality characteristics). A CTQ is a key measurable characteristic of a product or process.
2) ***Measure***: Translation of the problem into measurable data and measurement of the current situation.
3) ***Analyze***: Identification of influence factors and causes that determine CTQ behaviors.
4) ***Improve***: Design and implement adjustments and changes to the process to improve the performance of the CTQs.
5) ***Control***: Adjustment of the process management and control system in order to sustain improvements.

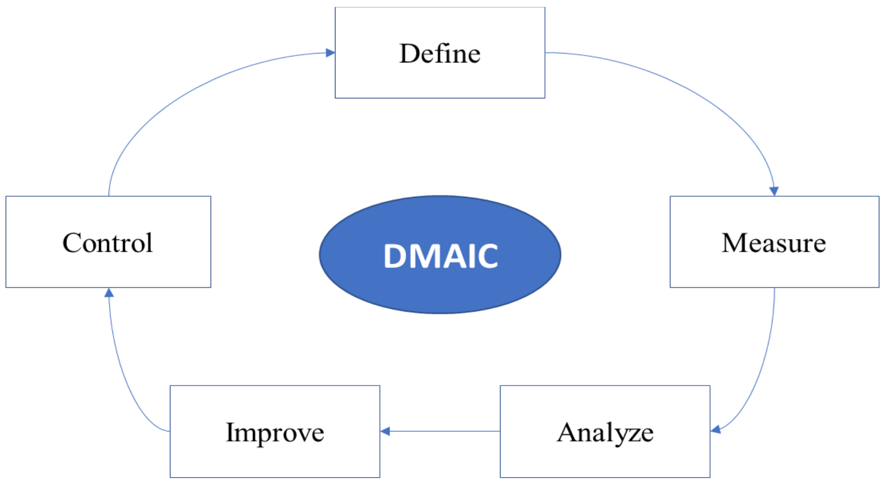


Figure 2.3. DMAIC phases

Brook (2017) identified the questions that should be set and the steps/goals that should be followed for the proper implementation of DMAIC phases, as presented in **Table 2.4**, starting from the definition of problem (Define phase) and continuing with the gathering (Measure phase) and the analysis (Analyze phase) of data for the proposal of the appropriate solutions for the improvement of operations/processes (Improve phase), and the checking and retainment of the improvement benefits (Control phase).

Table 2.4. DMAIC steps and goals

DMAIC Phase	Questions to be answered	Steps/Goals
Define	▪ What is wrong?	Definition of the business case
	▪ What do we want to achieve?	
	▪ How does the problem lead to the customer (the customer of the final product/ or the customer of the process, next process)?	Understanding of the customer/next process
	▪ Are we clear which process the problem relates to?	Definition of the process
	▪ Who, where, when and how will implement the project	Managing of the project
Measure	▪ How do we measure the problem?	Development of process measures
	▪ When and where does the data come from?	Collection of process data
	▪ Does the data represent what we think it does?	Checking of the data quality
	▪ How does the process currently behave	Understanding the process behaviour
	▪ What is the current performance of the process with respect to the customer/next process?	Calculate process capability and potential
Analyze	▪ How does the process actually work?	Analysis and modeling of the process
	▪ What does the existing process knowledge say?	Development of theories and ideas (potential root causes)
	▪ What does the data say?	Analysis of the data

DMAIC Phase	Questions to be answered	Steps/Goals
	▪ How does the root cause affect the output?	Verification of root causes and understanding of cause and effect
Improve	▪ What are all the different possible solutions?	Generation of potential solutions
	▪ Which solutions are most likely to work?	Selection of the best solutions
	▪ What are the risks of implementing the solutions?	Assessment of the risks
	▪ When, where and how the solutions will be implemented?	Implementation of pilot (temporary) and permanent solutions
Control	▪ How will the process be measured after the improvement?	Implementation of ongoing measurement
	▪ Have the changes become “business as usual”?	Standardization of the solutions
	▪ Has the project goal been achieved?	Quantification of the improvement
	▪ Does the project have a clear closure process?	Presentation of the results and closing of the project

As referred by Tenera and Pinto (2014), the incorporation of DMAIC in LSS projects helps not only in the effectiveness but also in the achievement of innovative results, arguing that several benefits can be provided:

- Proper statistical process knowledge to better understand and improve future results;
- A solid step-by-step method and a toolset for process improvement;
- Decisions based on facts and concrete quantitative analysis.

Hence, DMAIC is the appropriate method to follow for the successful implementation of an LSS project as also mentioned by Chakravorty and Shah (2012).

2.1.2.2 LSS Tools per DMAIC phase

For the implementation of DMAIC there are several tools that can be utilized in each DMAIC phase. In this section a brief description of every LSS tool (that is proposed to be used in the developed framework), categorized in the appropriate DMAIC phase, is presented. These tools are the most applied and widely recognized and their description and analysis that follows is based on the books of Allen (2019), The Council for Six Sigma Certification (2018), Brooks (2017), Burghall et al. (2014), Furterer (2014), Martin (2014), Khan (2013), Hambleton (2008), Bass (2007) and Sleeper (2006).

2.1.2.2.1 Define Phase

- ***Brainstorming***

Brainstorming can be used for the discussion and the consideration of possible root causes to a type of failure. Brainstorming sessions is a useful technique for the extraction of inferences about the AS-IS operation of the process that needs improvement. In these sessions, people coming from various levels of the organization should participate in order to give the discussion their own view and for the capturing of the different impressions regarding the problem. The brainstorming technique can be also utilized in the Analyze phase for the facilitation of the usage of other LSS tools, such as Fishbone Diagrams or 5-Whys.

- ***CTQ Tree***

Critical to Quality factors (CTQs) are the internal critical quality parameters that relate to the wants and needs of the customer. CTQs are what is important to the quality of the process or service to ensure the things that are important to the customer and constitute a measurable characteristic (De Koning and De Mast, 2006). CTQ trees help to provide more clarity and a more structured view to the VOC. The structure of a CTQ tree is shown in **Figure 2.7** and a typical an example of CTQ tree is presented in **Figures 2.8 and 2.9**.

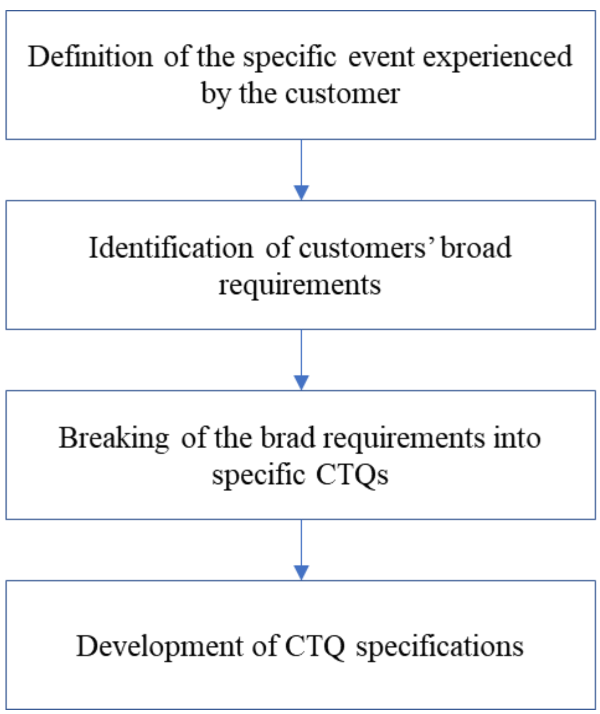


Figure 2.4. Structure of CTQ tree

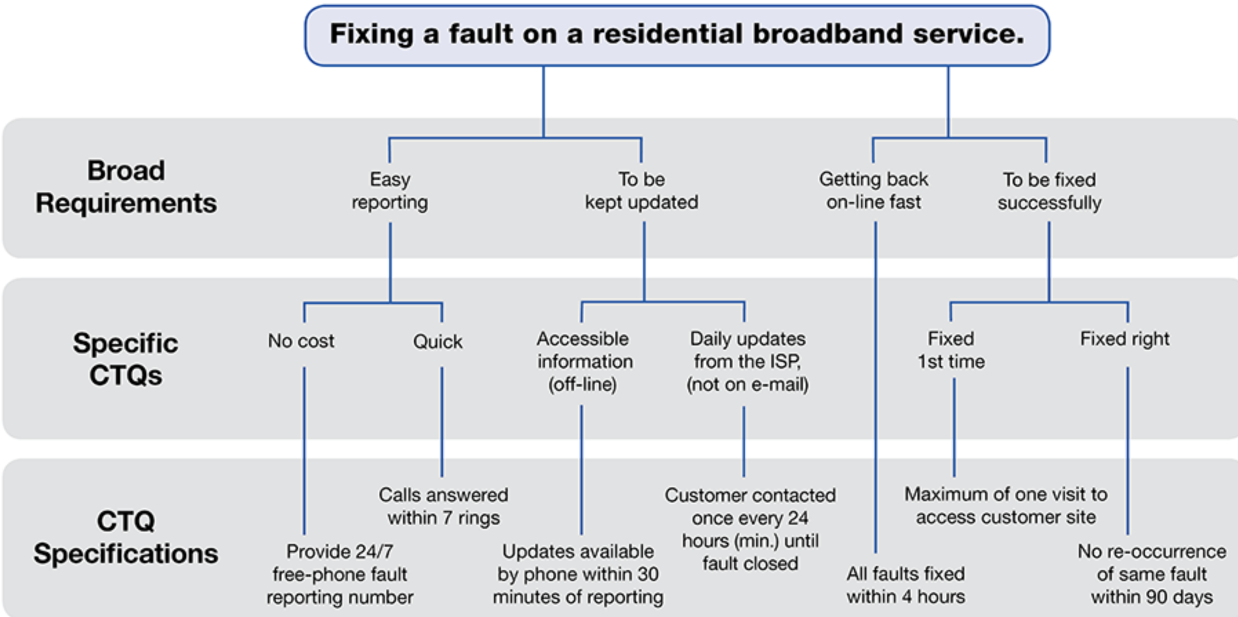


Figure 2.5. Example of CTQ tree in a service company (Source: Brook, 2017)

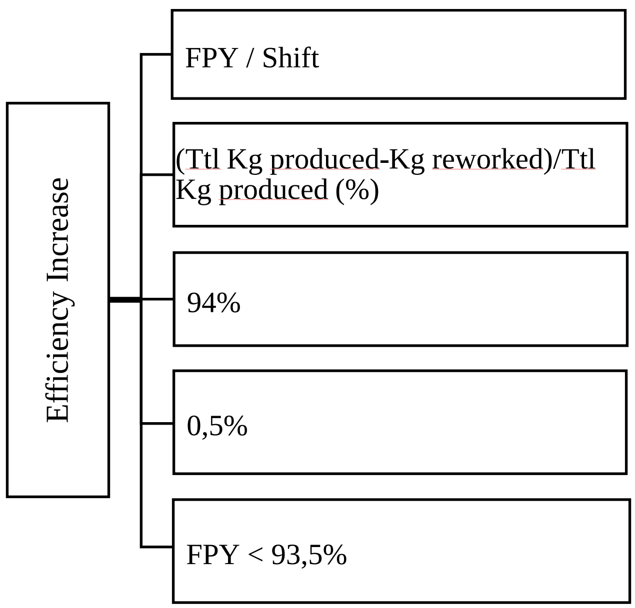


Figure 2.6. Example of CTQ tree in a manufacturing company (Source: Panayiotou, Stergiou and Chronopoulos, 2021)

- ***Process Map***

Process map is a tool that can be used in Define, Analyze and Improve phases depending on the needs of the project. Process mapping is a way of visually representing a process in order to identify how it really works and it is the basis for further process analysis. This tool helps in giving clarity to complex process and highlighting aspects useful for the improvement project, such as value-added/non-value-added activities, reductant or repeated processes, rework loops, and decision points. It can be utilized for depicting both current state (Define or Analyze phase) and future state (Improve phase) of process. A typical example of process mapping is the modeling of processes and activities through Business Process Model and Notation (BPMN) diagrams, in which the development of the reference model is based. Even more simple flow charts can be used for the depiction of the process steps. In **Figure 2.10** a BPMN diagram of the reference model is represented.

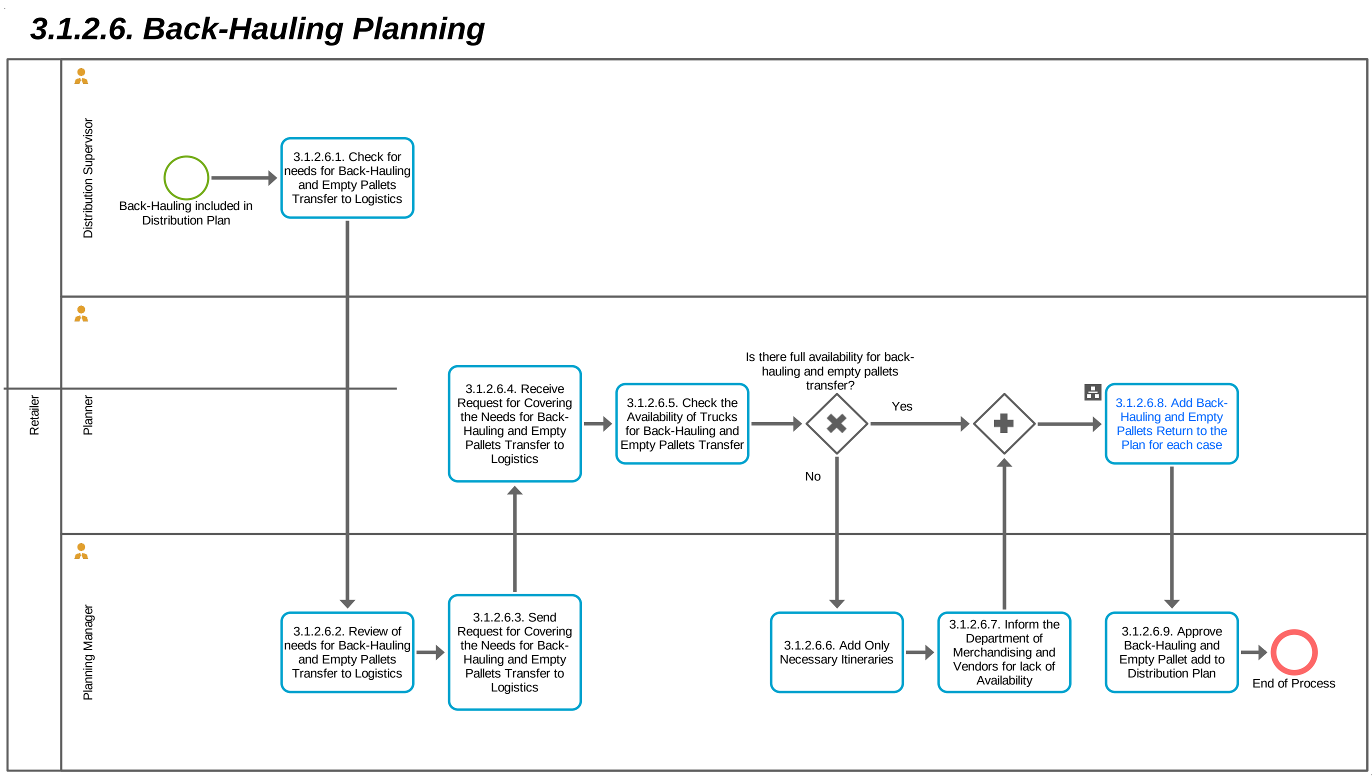


Figure 2.7. Example of a BPMN process map

- ***SIPOC***

SIPOC stands for Supplier, Input, Process, Output and Customer. It is a diagram, prior to process mapping, that helps in the clarification of the core processes that a project is focused on. SIPOC starts with a simple definition of the process. Then, the key steps (4-7) of the process are expanded at the bottom of the diagram. After that, the main inputs and outputs of the processes are listed and finally, the suppliers and customers of each input and output respectively are defined. An example of a SIPOC diagram is presented in **Figure 2.11**.

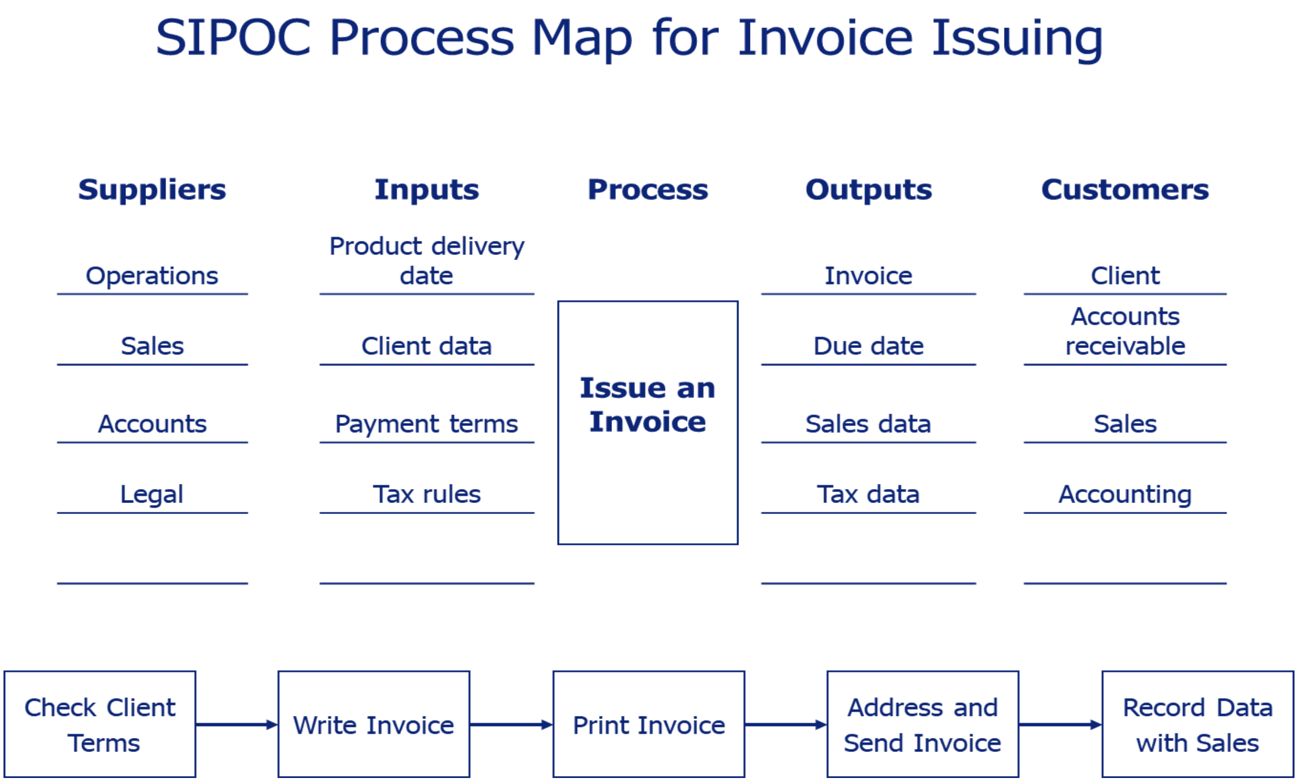


Figure 2.8. SIPOC example (Source: Brook, 2017)

- ***Value Stream Map***

Value Stream Map (VSM), as well as Process Mapping, which has been previously described, is a tool that can be used in Define, Analyze and Improve phases. It can be utilized for projects that are focusing on improving flow and efficiency and reducing waste. A VSM helps in the understanding of the flow of products (or services) through a process and identifies key materials and information flows. VSM can be depict the current state of the process (Define, Analyze) or the future state (Improve) after the decision for solutions.

The symbols that can be used for the configuration of a VSM are presented in **Figure 2.12**. Data boxes are very important as they provide the process flow with information related to the improvement project. Data that are useful to be collected in order to be included in data boxes of VSM are: times (cycle, set-up, queue, changeover, transport), inventory locations and levels, number of people/machines, batch (lot) sizes and pack sizes, defect rates coming from both scrap and rework, planning information (e.g., shipping schedules and production plans), customer shipment and demand rates (takt time), changeover frequency and product variations. An example of VSM is presented in **Figure 2.13**.

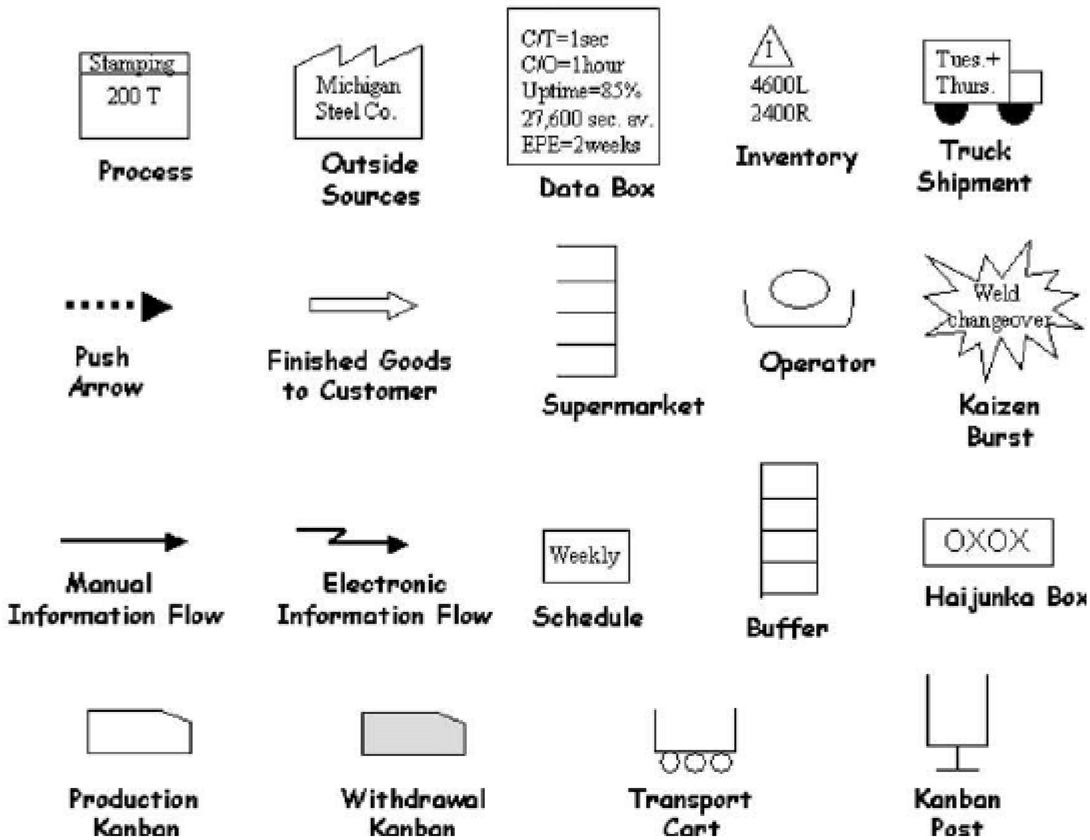


Figure 2.9. Common Symbols of VSM (Source: Radenkovic, Milan & Jeremic, Branislav & Todorovic, Petar & Djapan, Marko & Milosevic, Marko & Mijovic, Pavle. (2013). Improvement of quality in production process by appliying kaikaku method. International Journal for Quality Research. 7. 585-594.)

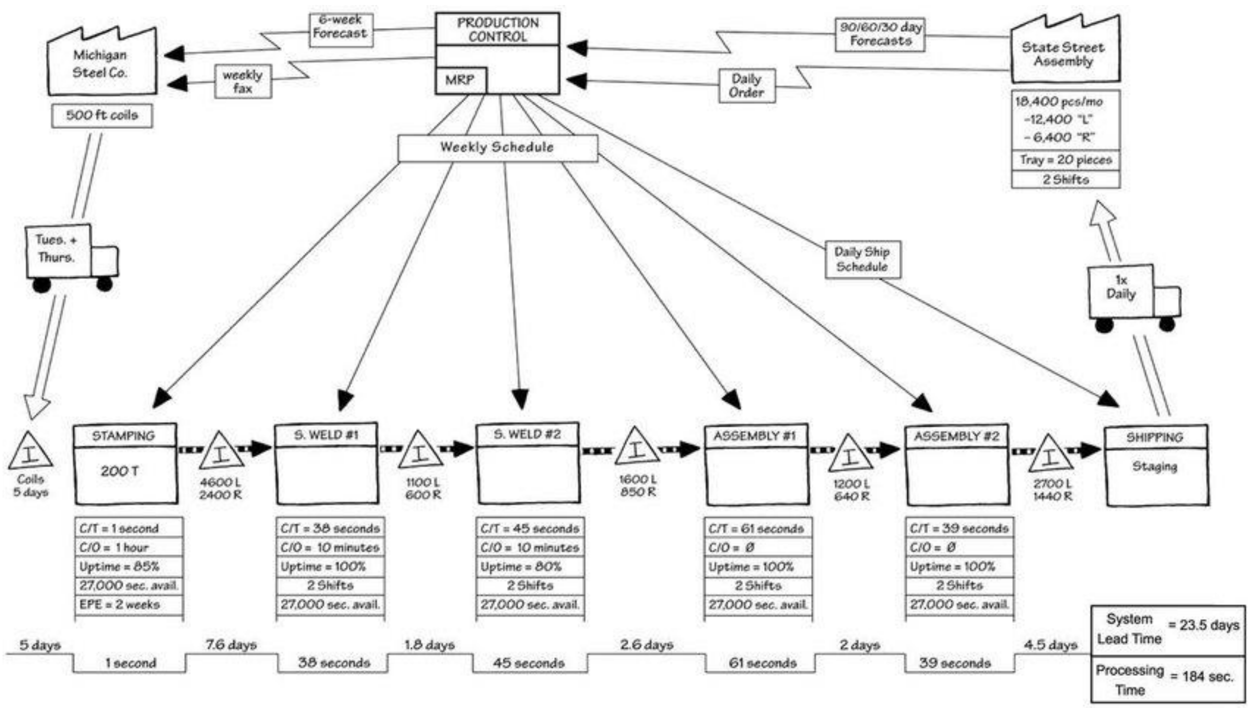


Figure 2.10. Example of VSM (Source: Shararah, Mohamed & El-Kilany, Khaled & ElSayed, Aziz. (2010). Component Based Modeling and Simulation of Value Stream Mapping for Lean Production Systems.)

- ***Voice of the Customer (VOC)***

The Voice of Customer is a tool that is used in almost every LSS project as it can help to the identification of the problems that the process customers (next processes) or the final product costumers are facing due to dysfunctions of company's operations. Problems detection can be occurred through:

- the gathering of customer complaints
- direct contact methods, such as phone calls, focus groups, and interviews
- less direct methods, like surveys, feedback cards, market research, and competitor analysis
- experiential methods, such as the execution of the problematic processes by the project team in real-time along with the employees to identify the problems all together. The project team can be also the customer of the product or the service of the company in order to inspect problems on own experience.1.

2.1.2.2.2 Measure Phase

- ***Data Collection Activities***

This is not a specific LSS tools, but an ad-hoc approach of data gathering, such as data collection forms for the measurement of specific characteristics of process (e.g., lead time, waste quantity, total production, etc.) completed by the employees of the process which is candidate for improvement.

- ***KPIs Tree***

Key Performance Indicators (KPIs) are metrics that reflect the performance pf the process. The KPIs should be carefully selected in order to measure the efficiency and effectiveness of a process. A KPI tree is a visual method of displaying a range of measures related to the process (or project in general), demonstrating the different measurement categories. In LSS projects, KPIs tress are utilized for the measurement of the CTQ specifications which have been configured in the Analyze phase. The metrics selected to be measured and depicted in the KPIs tree should follow a balanced approach and take under consideration all the factors affecting the performance of a process. In **Figure 2.14** an example of a KPIs tree is presented describing a process of fault repairs occurring to customers by a telecommunications company. It is evident that except the speed that is measured by the company in fixing faults, the customer satisfaction and the cost of repairing are also measured, as a balance should be retained among these factors because the increase or the decrease of one of them exclusively could negatively affect the others.

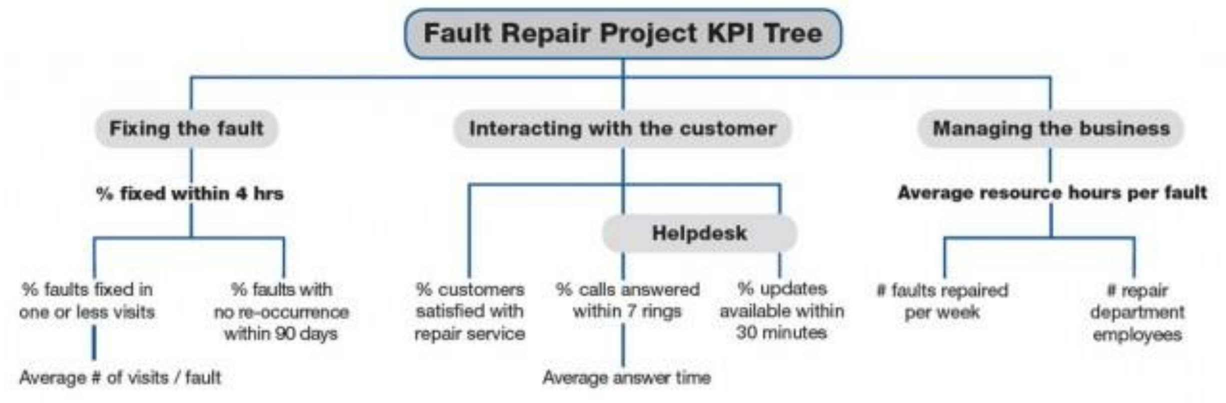


Figure 2.11. Example of a KPI tree (Source: Brook, 2017)

- ***Plots***

In Measure phase, as well as in Analyze phase, several plots and charts can be used for the depiction of the collected data. Examples of plots/charts are:

- *Histogram*: basic diagram for LSS projects as it represents the mean and the standard deviation (SD) of the data (**Figure 2.15**).

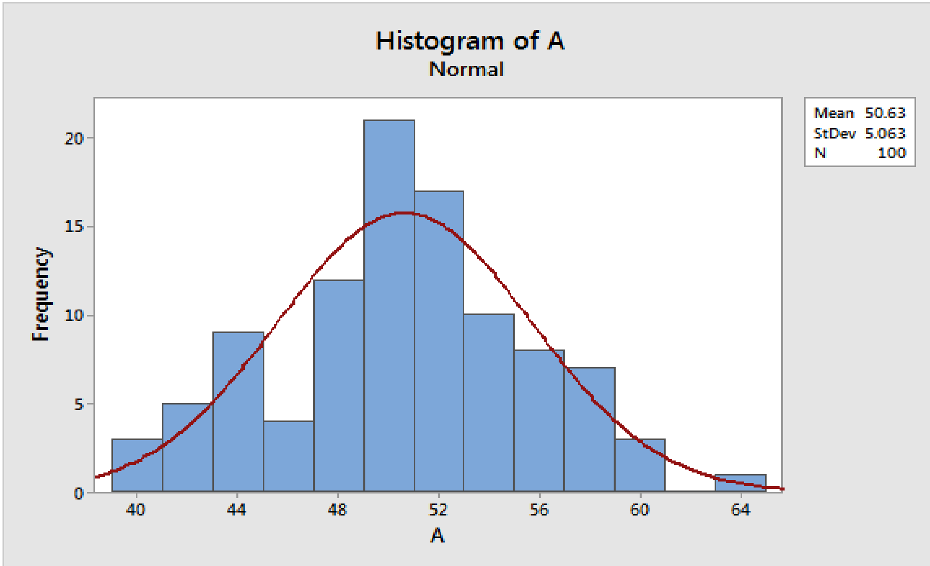


Figure 2.12. Example of histogram (Source: Using Histograms to Understand Your Data - Statistics By Jim)

- *Probability plot*: shows whether the fit follow the normal distribution (**Figure 2.16**). If all the data fall inside the two lines (upper and lower), representing the Confidence Intervals, then they are normally distributed.

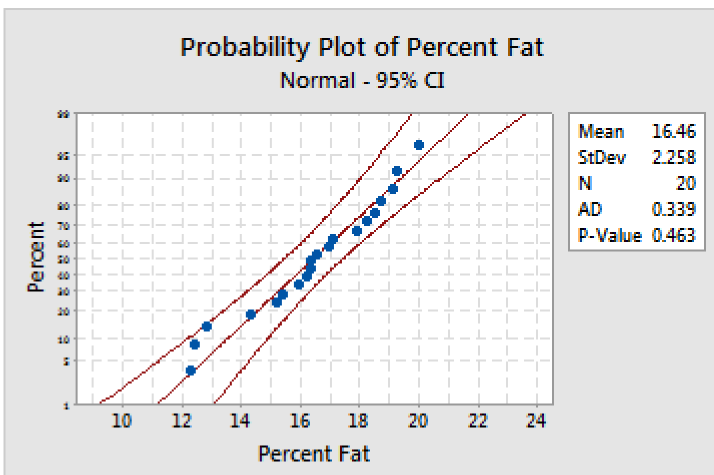


Figure 2.13. Example of [probability plot (Source: Example of Probability Plot - Minitab)

- *Time series plot*: line charts where the data is plotted in time order (the order in which it occurred. Time series plots reveal upward and downward trends, changes in the amount of variation, short-term and long-term differences, and repeating patterns or cycles (**Figure 2.17**).

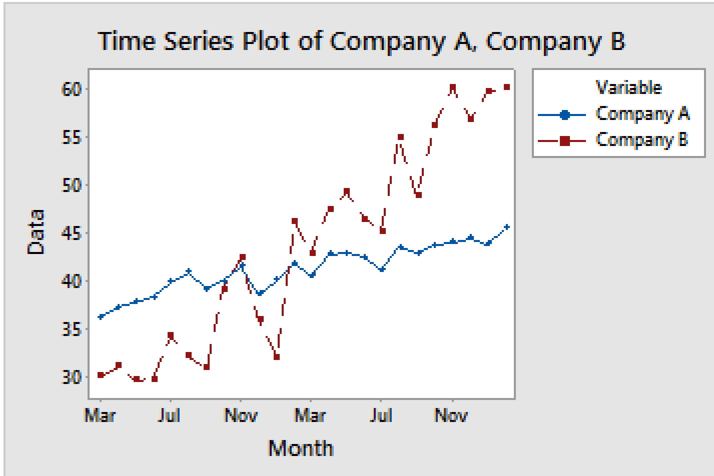


Figure 2.14. Example of time series plot (Source: Overview for Time Series Plot - Minitab)

- *Box plots*: this plot can be used for the comparing of samples of data against each other. They take key statistics from the data and summarize them in a box and whiskers format, as shown in **Figure 2.18**. The box represents 50% of the data. starting at Quartile 1 (Q1) and finishing at Quartile 3 (Q3). The middle of the box is the median. The whiskers represent the range of the data (minimum to maximum). The length of whiskers is limited to 1.5 times the length of the box. Any data beyond this constraint is considered to be outliers and are depicted with an asterisk or a dot.

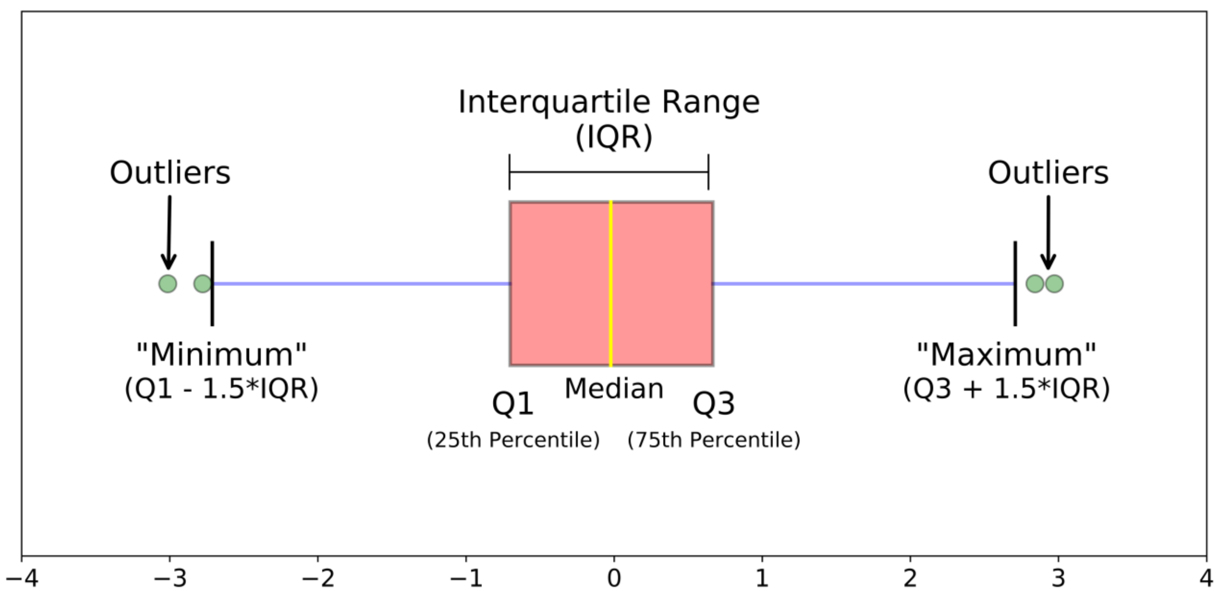


Figure 2.15. Boxplot format (Source: Understanding Boxplots. The image above is a boxplot. A boxplot… | by Michael Galarnyk | Towards Data Science)

- *100% stacked bar chart*: a useful chart for the depiction and comparison among proportions of categorical or attribute data (**Figure 2.19**).

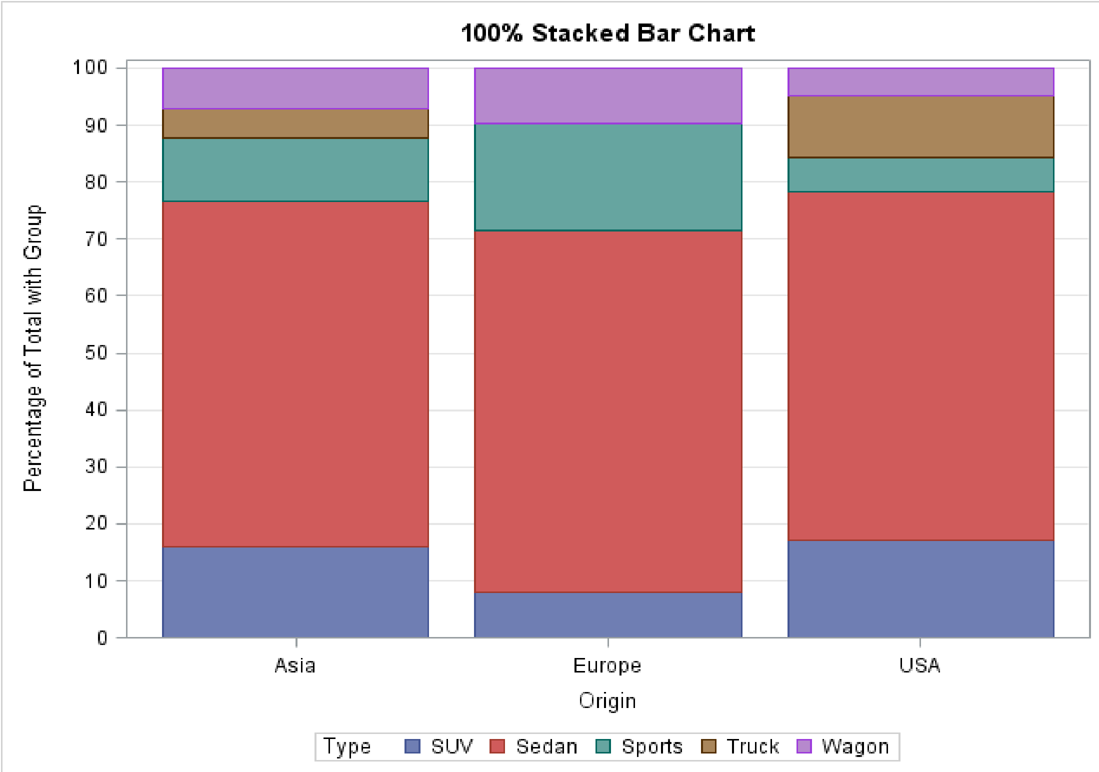


Figure 2.16. Example of 100% stacked bar chart (Source: Construct a stacked bar chart in SAS where each bar equals 100% - The DO Loop)

- ***Process Capability Analysis***

Process capability asses how well the process delivers what the customer wants, utilizing specific metrics (KPIs). Capability Analysis can be implemented to all types of data (continuous, count, attribute) - normal and non-normal - as long as their stability has been previously checked (through SPC charts). For the utilization of the analysis the USL (Upper Specification Limit), LSL (Lower Specification Limit) and the T (Target) of the process, set by the customer, should be defined along with the average and the deviation of the process. An acceptable process (**Figure 2.20**) is a capable (its range is significantly lower than the range of specification limits) and centered (its average is the same with the target of the specifications set by the customer) process.

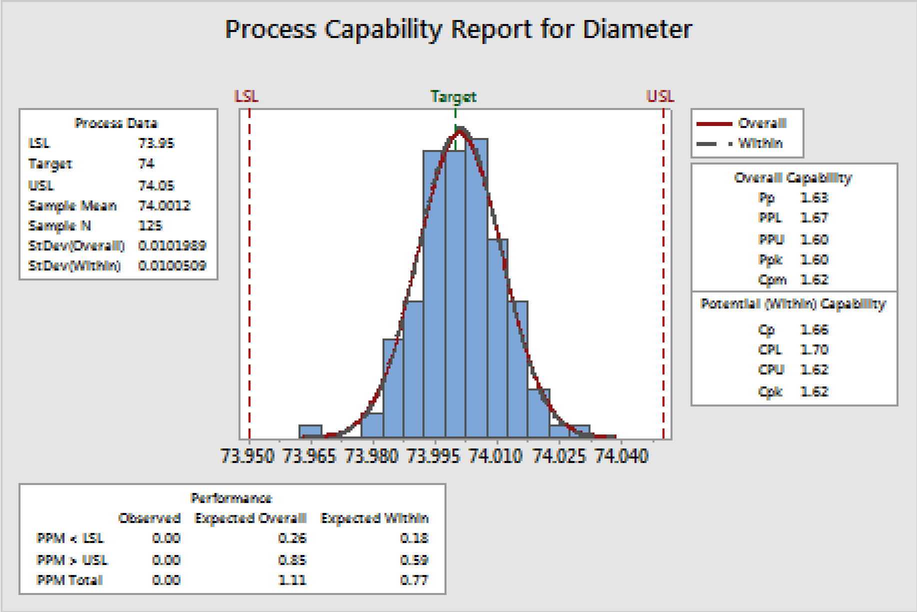


Figure 2.17. Example of acceptable process according to capability analysis (Source: Example of Normal Capability Analysis - Minitab)

The measures that are used in the capability analysis are Cp, Cpk, Pp and Ppk. The differences of these indexes is that their calculation differs in terms of the metrics that are used (mean and standard deviation). Cp and Cpk are short-term variability indexes taking under consideration the measures of a sample of measurements. Pp and Ppk are calculated using the metrics of the whole population, so they are long-term variability indexes. The reduction in the performance of the process long-term is the reason why Pp and Ppk are usually smaller than Cp, Cpk. Pp and Ppk indexes are much closer the real performance of the process as they give an overall view. The formulas of calculation of these indexes are:

- Cp = $\frac{UCL-LCL}{6s}$, s: sample SD, ideal Cp>1.5, acceptable Cp>1
- Cpk = $\frac{|(x-bar)-CSL|}{3s}$, x-bar: sample mean, s: sample SD, CSL: the specification limit closer to the mean of the sample, ideal Cpk>1.33, acceptable Cpk>1
- Pp = $\frac{UCL-LCL}{6\sigma}$, σ: population SD, ideal Pp>1.5, acceptable Pp>1
- Ppk = $\frac{|\mu-CSL|}{3\sigma}$, μ: population mean, σ: population SD, CSL: the specification limit closer to the mean of the population, ideal Ppk>1.33, acceptable Ppk>1

The Ppk and Cpk indexes are taking under consideration the centricity of the process, apart from the capability, and are always smaller than Pp and Ppk. If the process is centered, then Cp=Cpk and Pp=Ppk.

Other metrics included in capability analysis are:

- *Defects per Unit (DPU)*: the number of defective products divided by the total number of products. Everything that can go wrong in a process is considered as a defect, even if the result is acceptable.

$$\text{DPU}=\frac{(\text{total defects})}{(total\ units)}$$

- *Defects per Million Opportunities (DPMO)*: the average number of defects per unit produced per 1,000,000 "opportunities" for a defect to occur. The meaning of opportunity is any action that adds value to the product.

$$\text{DPMO}=\frac{\text{(number of defects measured in the sample)}}{(sample\ size)*(number\ of\ opportunities\ per\ unit\ in\ the\ smple\ )}*1{,}000{,}000$$

- *First Time Yield (FTY)*: the number of "good" units produced in a process to the number of units entering to it.

- *Sigma Level*: the number of standard deviations, from each side of a centralized procedure, following the normal distribution, found within specifications. Within the specifications in this case are the "good" pieces and outside the "scrap". The sigma level is the same as the Z value of the normal distribution. In **Figure 2.21** a normally distributed process is represented with its USL. Its sigma level is defined as the distance between the USL and the mean. The Sigma level can be calculated only if the processes is equated to a normally distributed process with just an USL. From the diagram it is obvious that as the process moves to the left (away from the USL) the sigma level will increase as the number of products outside the specification limit will decrease. Thus, higher sigma level means better performance and vice versa. (A table matching the sigma level with DPMO is presented in Section 2.2.1).

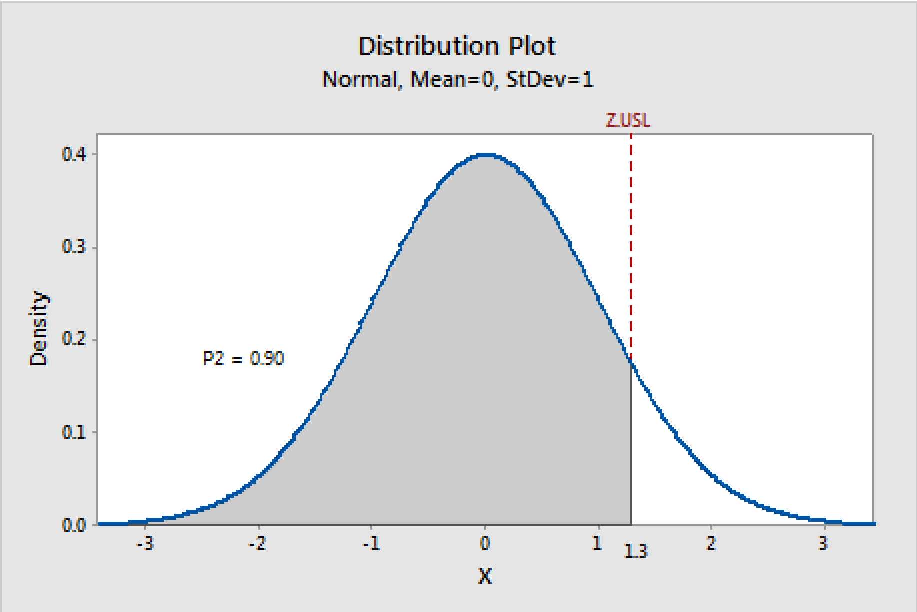


Figure 2.18. Graphical calculation of the sigma level (Source: Using the Z-score method to determine overall capability for nonnormal data - Minitab)

- ***Sampling***

The sampling is an analysis occurred after the determination of what to measure and how to record it, in order to decide the sample size and the sample frequency. The sample size depends on the type of data involved, the variation of the process, and the precision needed for the results. The sample frequency depends on any natural cycles occurring in the process, the precision required of the recorded data, and the volume of products (or services) produced.

The steps for the calculation of the Minimum Sample Size (MSS) for continuous data is presented in **Figure 2.22**. A rule of thumb for the estimation of the standard deviation, before the measurements, is to gather the historical data of the process and divide the historical range (the difference between the highest and the lowest measurement) by five. The steps for the calculation of the Minimum Sample Size (MSS) for attribute data is presented in **Figure 2.23**. The proportion of the process is estimated based on historical data. The attribute data needs a larger MSS than the continuous data, due to their lower resolution and quality.

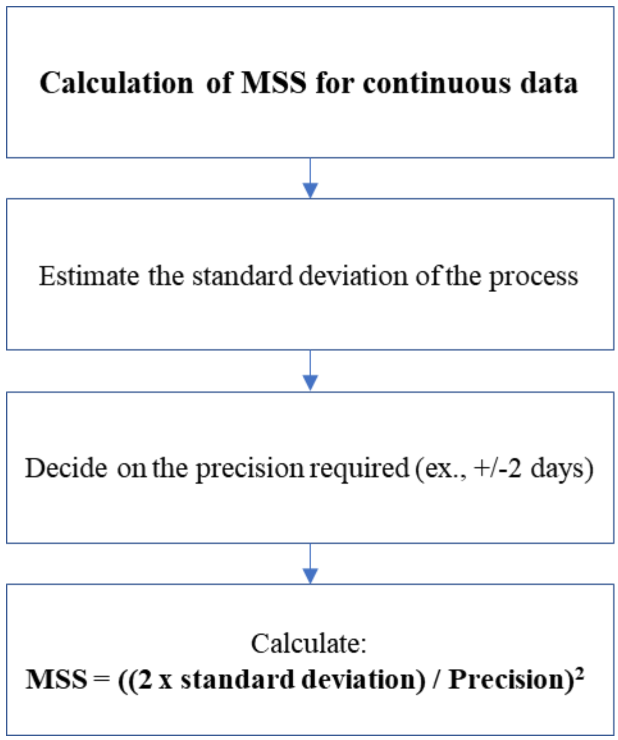


Figure 2.19. Steps for the calculation of the minimum sample size for continuous data (adapted from Brook, 2017**)**

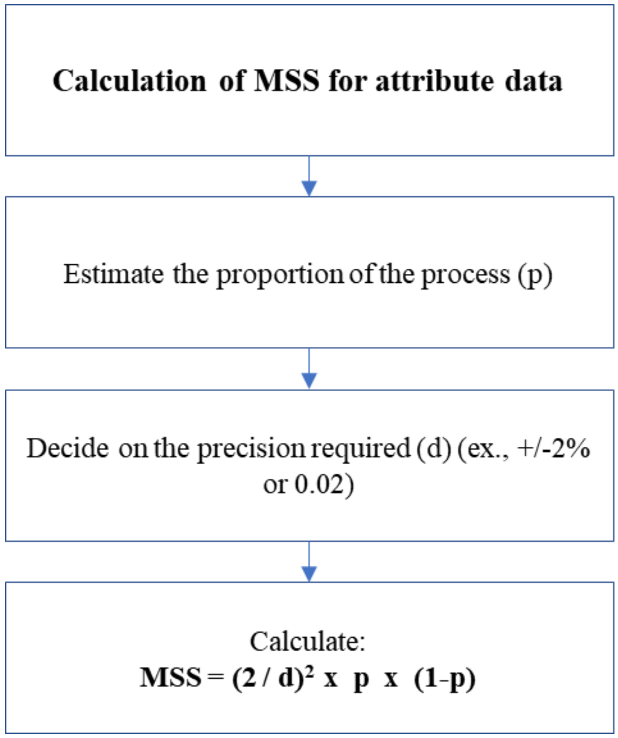


Figure 2.20. Steps for the calculation of the minimum sample size for attribute data (adapted from Brook, 2017**)**

2.1.2.2.3 *Analyze Phase*

In this paragraph a comprehensive and simple description of the metrics and the statistics that are used for the quantitative tools of this phase is conducted in order to be clear how the results of the tools are interpreted. The basic analysis, in which all the presented statistical tools are based on, is the *Hypothesis Testing*, which indicates how confident we can be in our decisions and our risk of being wrong. The structure of the Hypothesis testing is presented in **Figure 2.24**.

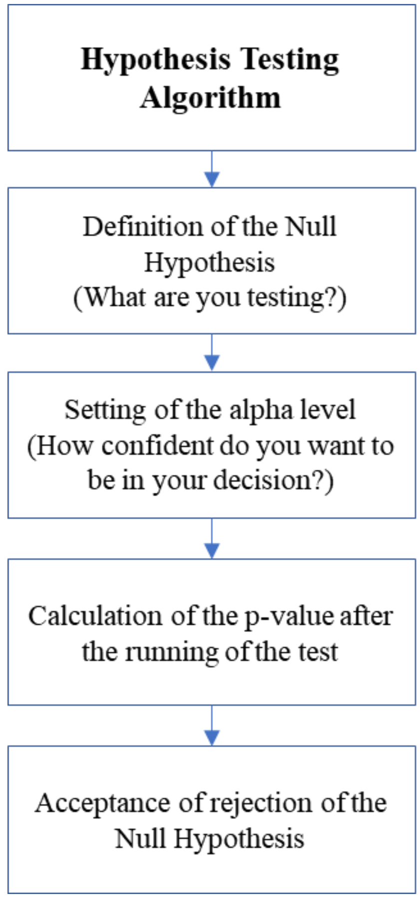


Figure 2.21. Hypothesis testing steps

The statistical tools (ANOVA/Chi-square, 2-sample or 1-sample t-test/proportion test, 1 sample sign test, Kruskal-Wallis Analysis, Mood's Median Test, Correlation and Regression Analysis, and DOE) which are described in this section are based on three important statistical notions:

- *Confidence Intervals (CI):* A statistic cannot not be absolutely accurate, that's why CI can be used to provide a range within which the true process statistic will fall (with a specific level of confidence). A usual confidence level that is used is 95% (others are 90%, 97.5%, 99%). A simplified mathematical equation for the calculation of a 95% CI for the average of a population is: $CI = Sample\ Average \pm t \times (\frac{Sample\ Sigma}{\sqrt{n}})$, *n* is the sample size and *t* is a metric taken from statistical tables which is bigger for larger CI.

- *p-value*: The p-value is the probability of getting results other than Null hypothesis, assuming that the null hypothesis is true. This practical mean that if the p-value is low (lower than the alpha level) then the Null hypothesis should be rejected and when it is not low (higher than the alpha level) then the Null is kept.

- *Alpha level or significance level*: Alpha level is the probability of making the wrong decision to reject the Null hypothesis, even if it is true. For this reason, if the p-value is lower than the alpha level and the alpha level has been set to 0.05 (or 5%), then we are (at least) 95% confident that the Null hypothesis it is not true, and we can reject it. Otherwise, we cannot reject the Null hypothesis.

- ***ANOVA (Analysis of Variances)/ Chi Square***

ANOVA is a technique allowing the analysis and comparison, for continuous data, of the averages with three or more samples at a time. The analysis reveals whether we can say that there is difference among the averages of the samples. The Null hypothesis is that there is no difference in the averages and the Alternative hypothesis is that there is a difference in at least one of the three averages. If the p-value is smaller than the significance level (usually 0.05), then we can confidently reject the Null hypothesis. For the utilization of the ANOVA the data are suggested to follow the normal distribution (it is not a prerequisite, but it gives certain results). For this reason, an Anderson-Darling normality test can be used in order to check our data. If the data are not normal, then a Johnson or Box-Cox transformation can be used. Chi-square is the same as ANOVA, but it is used for proportions or percentages.

- ***Correlation and Regression Analysis***

Correlation and Regression are essentially two similar tools which are used for the quantification of the relationship between process inputs and outputs. The steps that should be followed for the conduction of a Correlation and Regression Analysis are:

1. Configuration of scatter plot of the data
2. Checking for correlations through Pearson coefficient (r). The range of the r can be from -1 to 1 indicating very strong negative or very strong positive correlation respectively. Values from 0.7 to 0.9 or from -0.7 to -0.9 indicate high positive or high negative correlation. Values from 0.5 to 0.7 or from -0.5 to -0.7 show a moderate positive or negative correlation and from 0.2 to 0.5 or -0.2 to -0.5 indicate a low positive or negative correlation. Finally, for values under 0.2 or -0.2 the correlation between variables is negligible. In **Figure 2.25**, different scatter plots for different correlations are depicted. The prerequisite for the acceptance of the r value is the p-value of the analysis to be less than 0.05.

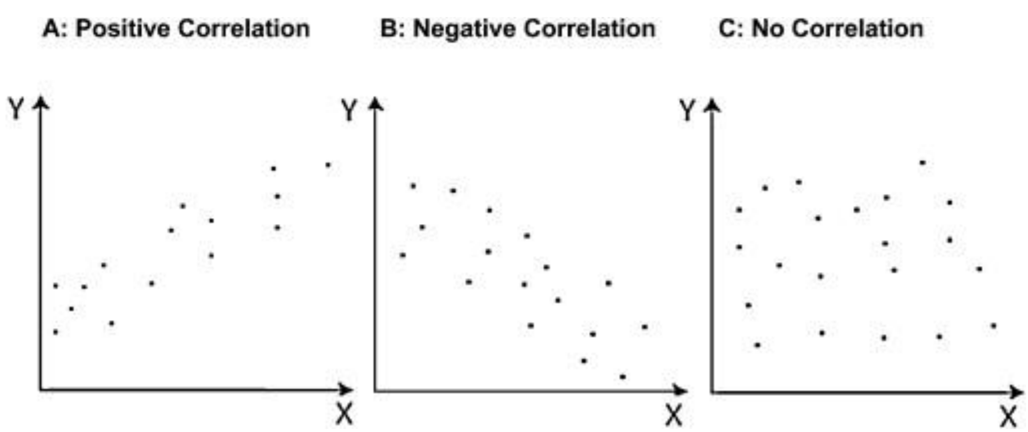


Figure 2.22. Scatter plot depicting different correlations (Source: Prematunga (2012)**,** Correlational analysis - ScienceDirect)

3. Conduction of first Regression Analysis. The regression analysis creates a line that best resembles the relationship between the process input and output. The line is called “the line of least squares” as it is the total of the squares of the errors (difference between data points and line) that is

minimized. For continuous input and output, simple or multiple regression can be used depending on the number of the input variables. The regression develops a mathematical model that represent the relationship of the data. For *linear regression* the model form is Y = m(X) + c. For *quadratic regression*, the model includes an x^2 term and for cubic contains a x^3 term. For continuous or/and attribute input and attribute output binary logistic regression can be used. An example of a simple linear regression analysis is presented in **Figure 2.26**.

4. Evaluation of the Regression Analysis. **Figure 2.26** depicts the mathematical model describing the relationship (the line with the red colour). The lines with the green colour represent the interval in which we can be 95% confident that the average will occur. The purple line are the prediction intervals and represent the interval within which we can expect the 95% of process output (data points) to occur. The R-Sq (R-Squared) value indicates for how much (the percentage) of the variation in the process output the input is responsible for. The more closely to 100% the better. Finally, in regression the distance of the data points from the regression line is called "residuals". The analysis of residuals can give information about the goodness-of-fit of the model (regression line) to the data. The result of this analysis can lead to a repetition of the analysis for the searching of another model.

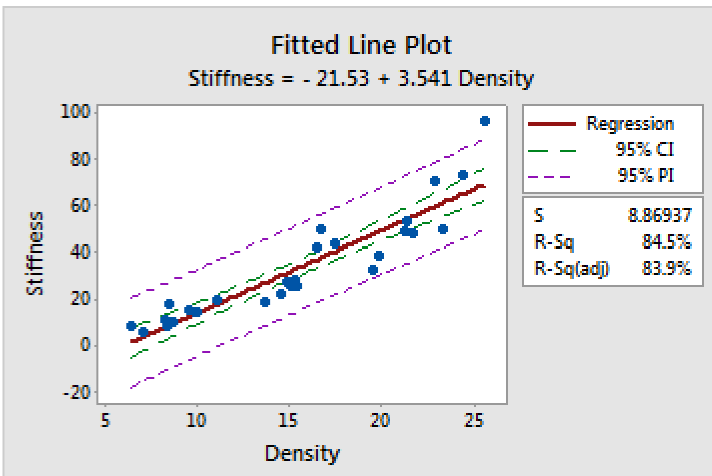


Figure 2.23. Example of simple linear regression (Source: Example of Fitted Line Plot - Minitab—)

- ***Failure Mode and Effect Analysis (FMEA)***

FMEA can be used during Analyze, Improve and even Control phase. This tool highlights the aspects of process or product that should be targeted for improvement (before the occurrence of possible failures). FMEA is actually a risk analysis tool, and it is useful if the aim is to prevent an event before happening or if the failure probability of a process is too low to learn from past failures. There are two types of FMEA that can be utilized in LSS projects. The products FMEA (**Figure 2.27**), which analyzes the function, design and failure of the components of products and the process FMEA (**Figure 2.28**), which analyzes the key outputs and potential failures of each step of a process and considers the impact of failures on the respective product or service.

Product Number: PT34325-4053	Market: Japan	Team: Alex Drinal, Peter Loombard, Katie Samdras, Lin Woodlord	
Product Name/Description: Ball Point Pen		Design Engineer Leader: Lin Woodlord	Document Number: DF325-12 / Orginal Date: Feb 10, 2019
Model: HandFree-P6	Year: 2019	Approved by: Mike Handson	Revision No.: 002 / Revision Date: May 14, 2019

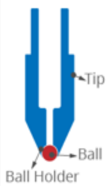
Item / Function	Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Classification	Potential Causes(s) of Failure	Current Design Controls Prevention	Occurrence	Current Design Controls Detection	Detection	RPN	Recommended Action(s)	Responsibility & Target Completion Date	Action Results: Actions Taken & Effective Date	Action Results: Severity	Action Results: Occurrence	Action Results: Detection	Action Results: RPN
Pen tip / disperses ink onto paper smoothly 	Delivery proper ink amount onto paper	Not enough ink	Pen skip or Required heavy pressure while writing	7	A	Ball diameter is too big	Study tolerance of ball diameter and line weight and color	6	Writing test to detect if problem occurs	3	126							
						Narrow pen angle when writing	Study common range of writing angle	4		10	280	Writing Test with varying pen angles of the pen	Katie Nov, 24		7	3	2	42
						Not enough presure on the pen	Study the minimum presure of users and make sure ink can be dispnersed with minium presure	4	Writing test with minum presure on the paper	2	56							
		Too much ink	Globs or drip left behind the letters	7	A	Ball diameter is too small	Study tolerance of ball diameter and its effects to line weith and color	3	Writing test to detect if problem occurs	3	63							
						Pressure of user on the pen too much	Study user's pressure range	3	Writing test with high presure	3	63							
	The ball runs smoothly	Smoothly	Inconsistent line Skip or Glob left behind	8		Inproper selection of dimenson of the ball and ball socket	Study the tolerance of ball and ball socket and select the correct range	4	Writing test with miniumum presure on the paper	2	64							
						Improper selection of the ball roughness tolerance	Select surface roughness base on the standard	2	Check the prototype capability of ball surface	3	48							

Figure 2.24. Example of FMEA for products (Source: DFMEA - Complete Guide to the Design FMEA | IQASystem)

Func	Potential Failure Mode	Potential Effect of Failure	Sev	Potential Cause of Failure	Occur	Current design controls	Detec	RPN	Recommended Action	Action Results			
										Sev	Occ	Det	RPN
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*	*m*	*n*
FP1	Distortion of the headlining	Unsatisfied customer	8	Wrong design of the part on the rigidity	5	Capitalisation project vehicle	1	40					
FP2	Distortion of the headlining	Unsatisfied customer	8	- Part in interference with the car body	5	-Validation by simulation -Capitalisation project vehicle	3	120	Design review of the part	6	4	3	72
FP2 FC2 FC3	Assembly of the technical environment parts are not possible	Unsatisfied customer	8	- Wrong design of the part on the mounting hole - Wrong fixation	5	-Validation by simulation - Dimensional chain Capitalisation project vehicle	3	120	Design review Review of the dimensional chain	6	4	3	72
FP2 FC2 FC3	Mounting of the headlining is not possible	Unsatisfied customer	8	- Wrong design of the fixation points - Wrong cutting - Wrong design of the mounting kit	3	-Validation by simulation - Dimensional chain -Capitalisation project vehicle	3	72	Design review of the part Review of the dimensional chain	5	3	2	30
FP2 FC2 FC3	Wrong joint of the components	Unsatisfied customer	8	- Wrong cutting of part - Wrong design of the mounting kit	5	-Validation by simulation - Dimensional chain - Capitalisation project vehicle	3	120	Design review of the part Review of the dimensional chain	6	4	3	72
FP2 FC1	Bad aspect of the part	Unsatisfied customer	8	- Wrong choice of material	5	- Capitalisation project vehicle	1	40					
FC1	Poor resistance to the environment	Unsatisfied customer	8		5	- Capitalisation project vehicle	1	40					
FC5	Non-conforming results of the tests	Unsatisfied customer	8	- Wrong choice of material	5	- Capitalisation project vehicle	1	40					
FP1	Vibrations	Unsatisfied customer	8	-Wrong design of part - Poor connection of part with the car body and with the other environment parts	5	Validation fixing points by simulation	3	120	Design review of the part	6	4	3	72

Figure 2.25. Example of FMEA for process (Belu et al. (2012), Source: (5) (PDF) Application of FMEA method in product development stage (researchgate.net))

The FMEA process consists of the following steps:

- Identification of the process steps or components of the product

- Listing of the different failure modes of each process step or product component, and rating of their severity (SEV) usually on a scale of 1-10.
- Consideration of the different potential causes that might lead to the failure and rating of their occurrence (OCC), for each potential cause.
- Consideration of the controls that exist to prevent each potential cause to happen and detection of the failure if the cause occur, along with the rating of the likelihood of detection (DET).
- Calculation of the Risk Priority Number (RPN) for each potential failure by multiplying the SEV by OCC by DET,
- Assigning actions to confront the highest RPNs and reviewing the progress.

- ***1-sample or 2-sample t-test (or proportion tests)***

1-sample t-test is used, for continuous data, for the analysis and comparison of a sample average with a known average value, such as an industry benchmark or a historical average. 2-sample t- test is used for the analysis and comparison of the averages of two different samples in order to find out whether there are differences. It is not necessary for the samples to be the same size. The Null hypothesis is that there is no difference in the averages and the Alternative hypothesis is that there is a difference in averages. If the p-value is smaller than the significance level (usually 0.05), then we can confidently reject the Null hypothesis. For the utilization of the 1-sample or 2-smaple t-test the data are suggested to follow the normal distribution (it is not a prerequisite, but it gives certain results). For this reason, an Anderson-Darling normality test can be used in order to check our data. If the data are not normal, then a Johnson or Box-Cox transformation can be used. 1 or 2 proportion test is the same as 1-sample or two sample t-test respectively, but it is used for proportions or percentages.

- ***1 Sample Sign Test, Kruskal-Wallis Test Mood's Median Test***

These tools are used for the same analysis as sample t-tests or ANOVA, but for non-normal data. All three tests take under consideration the medians of the samples in order to conduct the analysis. Specifically, 1 sample sign test compares the median of a sample against a known median value, coming from historical data or industry benchmarks. If in the result of the analysis the p-value is lower than the alpha level (usually 0.05), then the null hypothesis can be rejected and conclude that there is difference in medians. The Kruskal-Wallis test compares the medians of different samples of data, when there are no or few outliers. If the p-value of the analysis is lower the 0.05, then the null hypothesis is rejected, and the inference is that there is difference in medians. The Mood's median test is used in the same exact way as Kruskal-Wallis for comparing the medians of different samples of data, when there are many outliers. The Mood's median test output includes also an estimated range of medians difference, depending on the selected Confidence Interval.

- ***5-Whys***

The 5-Whys tool helps in the investigation of a specific failure in order to find the real root cause. The identification of a cause of a problem can sometimes be occurred by keep asking why until the real root of the problem comes to the surface. An example of 5-Whys is depicted in **Figure 2.29**.

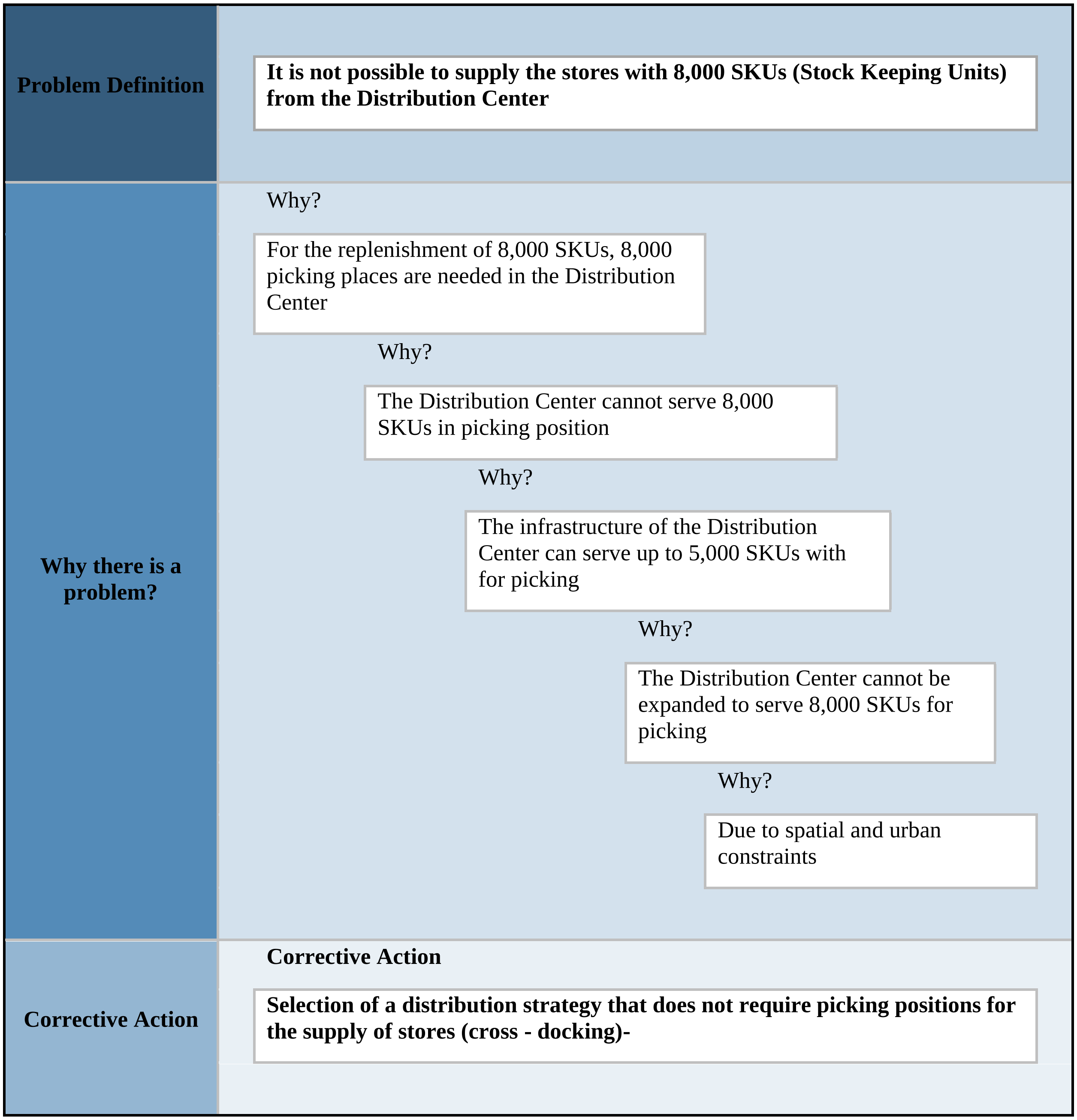


Figure 2.26. Example of 5-Whys in a retail supply chain problem

- ***Fishbone Diagram***

Fishbone (Cause and Effect) diagrams is a tool for structuring the different causes that may lead to an undesirable effect. Fishbone can be used in both Analyze and Define phases in order to support brainstorming sessions about the problems occurring in a process. An example of the factors resulting in the need of rework in a chocolate production factory is presented in **Figure 2.30**. The categories of factors affecting the problem include, but are not limited to, machine/equipment, methods, material, environment, people, measurements, etc.

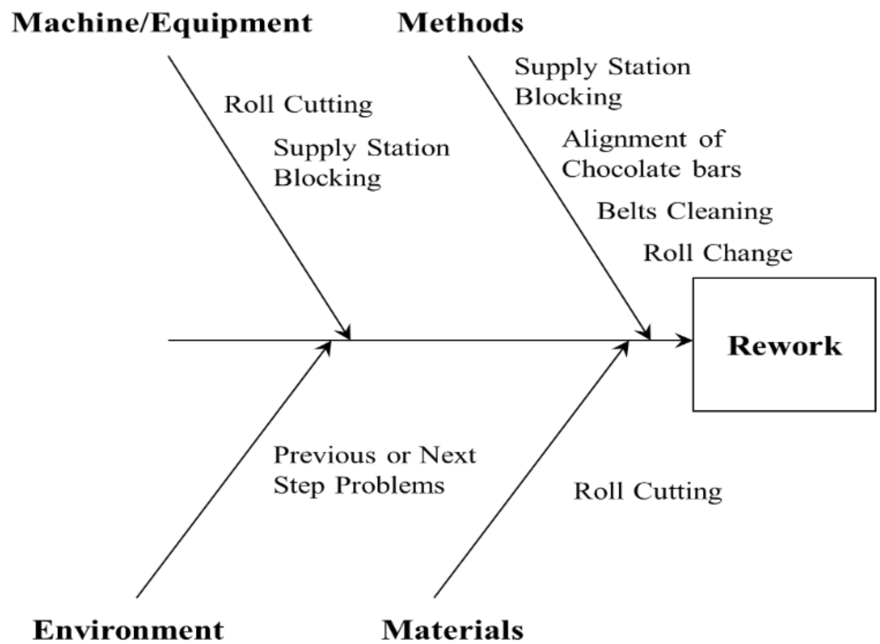


Figure 2.27. Example of a fishbone diagram (Source: Panayiotou, Stergiou and Chronopoulos, 2021**)**

- ***Pareto Diagram***

A Pareto Diagram is bar chart which is used for categorical data, where the most frequent results are placed in order from the left side. **Figure 2.31** presents the frequency of defects occurred in each department of a manufacturing company. The cumulative frequency is plotted as a line and shows the total count of defects per department combined. The exact numerical results are given by the table at the bottom of the diagram. The reasons for failure are often found to follow the 80/20 rule (Pareto Principle), which states that the 80 percent of the failures/problems/defects are caused by the 20 percent of the root causes (Sanders, 1987).

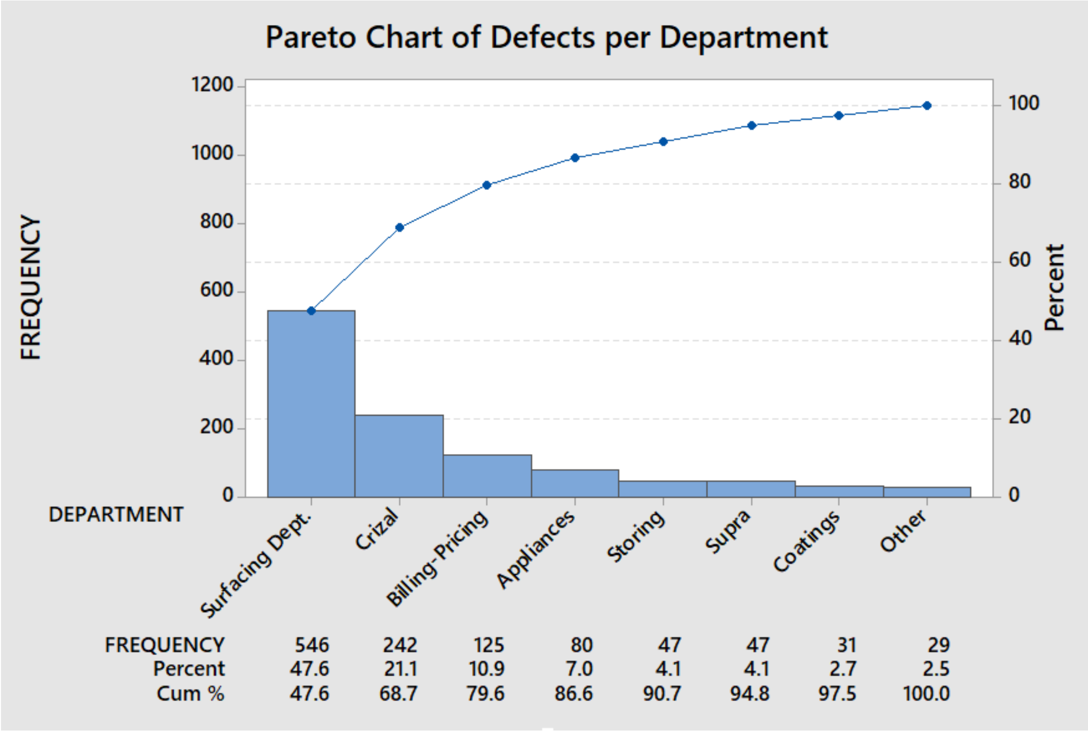


Figure 2.28. Example of a Pareto diagram (Source: Panayiotou, Stergiou and Panagiotou)

- ***Charts and Graphs***

The charts and graphs that has been described in the measure phase and are proposed for the organizing of the measured data can be also utilized in the Analyze phase for the extraction of useful inferences about the current situation of the process, or the operational problems that are taken under consideration for improvement.

2.1.2.2.4 Improve Phase

- ***Cost-Benefit Analysis (CBA)***

Cost–Benefit Analysis (CBA), is a systematic approach for the estimation of the strengths and weaknesses of alternatives used in order to determine the options which provide the best approach to achieve benefits, while preserving savings (e.g., in activities, and functional business requirements) (Rodreck et al., 2013 wiki). The generic steps of CBA according to Berman et al. (2008) are:

1. Definition of the objectives of the actions and investments that should be undertaken.
2. Gathering of all the data and information needed for the cost of the potential investment.
3. Determination of the benefits of the investment for the company. What will be the cost reduction and how the profits will be increased?
4. Determination of the discount rate (interest rate utilized for the calculation of the present value) that the company desires. Calculation of the Net Present Value (NPV) of the investment using the desired discount rate.

5. Calculation of the Payback Period and the Internal Rate of Return (IRR).
6. Evaluation of the potential investment.

The three basic metrics which are utilized for the CBA and the appraisal of an investment are:

- Net Present Value (NPV): It takes under consideration the value of money over time, by transferring the future cash flow to the present. The cost of capital of the company is also taken under consideration or the IRR. The formula for the calculation of the NPV is:

$$NPV = \sum_{t=0}^{N} \frac{R_t}{(1-i)^t}$$

where, R_t is the incoming cash flow due to the investment in the upcoming time period, i is the discount rate which transforms the future value of an investment to present value (i.e. the return that could be earned per unit of time on an investment with similar risk) and t is the number of the time periods.

- Payback period: It is the time needed for the incoming cash flow by the investment to return the spent money.
- Internal Rate of Return (IRR): It calculates the real return of the investment based on the incoming cash flows. It is the discount rate that can make NPV = 0. If IRR > i, then the investment is acceptable. If IRR < i, then the investment is unacceptable, and if IRR = 1, then the investment is indifferent.

Finally, there is the Benefit-Cost Ratio (BCR) which shows the relationship between the relative costs and the benefits of an investment. The formula of BCR is:

$$BCR = \frac{\sum Present\ Value\ of\ Future\ Benefits}{\sum Present\ Value\ of\ Future\ Costs}$$

If a project has a BCR that is greater than 1.0, the investment is expected to deliver a positive NPV and will have an IRR above the discount rate. If the BCR is equal to 1.0, the ratio indicates that the NPV of expected profits equals the costs. If an investment's BCR is less than 1.0, the costs outweigh the benefits, and it should not be considered.

- ***Simulation***

Simulation, according to Shannon (1975), is "the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system." According to Snow (2003) a simulation model has 'entities' (e.g. machines, materials, people, etc.) and 'activities' (e.g. processing, transporting, etc.). The logic governing each activity is also described. For example, processing activities are able to start only when a certain quantity of working material is available. Once an activity has started, the time needed for its completion is calculated, often using a sample from a statistical distribution. The model starts and continues to run over the predefined time, following the logical rules that have been set up. Results are then extracted concerning throughputs, delays, waiting times, etc. For the better interpretation of the results the "warm-up" time should be taken under consideration. The warm-up time is the time that the simulation will run before starting to collect results. This allows the Queues (and other aspects in the simulation) to get into conditions that are typical of normal running conditions in the system that is simulated.

According to Muralidhar (2003) there are three categories of simulation:

1. *Monte-Carlo Simulation*: The principle of Monte-Carlo simulation is that the behavior of a statistic in random samples can be assessed by the empirical process drawing many random samples and observing this behavior. So, it relies on repeated random sampling and statistical analysis to compute the results.
2. *Discrete-Event Simulation*: Discrete-event simulation (DES) is used for the modeling of real-world systems that can be decomposed into a set of logically separate processes that autonomously progress through time. Each event occurs on a specific process and is assigned a logical time (a timestamp). The result of this event can be an outcome passed to one or more other processes. The outcome might result in the generation of new events to be processed at some specified logical time in the future. DES is supported by the statistical paradigm that is based in queuing theory.
3. *Continuous Simulation*: Continuous simulation deals with the modeling of physical (or not) events (processes, behaviors, conditions) which can be described by some set of continuously changing dependent variables. The variables change in a continuous way (but not abruptly) from one state to another.

The combination of the event-based timing of discrete-event simulation and the continuous variables calculations of continuous simulation constitute the *Discrete Rate Simulation*. This type of simulation predicts and schedules events when there is a need for the calculation of a new set of rates and determines the appropriate rate of flow for each branch or stream.

2.1.2.2.5 Control Phase

- ***I-MR Chart***

I-MR Charts (Individual - Moving Range) are used with continuous data that does not have any rational groups (all the data points have been collected individually) and depict the stability of the process. For the deployment of I-MR charts, in order to statistically control the process, the data are better to be normally distributed. In **Figure 2.32** an example of an I-MR chart is represented. I-MR charts are the combination of two statistical process control (SPC) charts. The *Individuals (I) chart* which a time series plot of data with control limits (UCL-Upper Specification Limit, LCL-Lower Specification Limit), and the *MR (Moving Range) chart* which shows the moving range (the difference between two consecutive points) of the data of the I-chart. The range of the process can give information about the changed in the variation of the process.

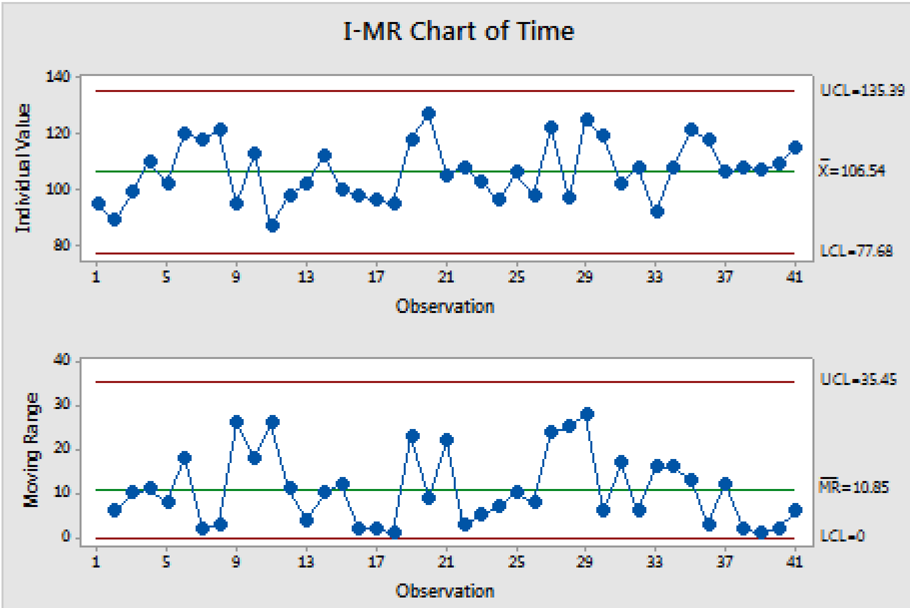


Figure 2.29. Example of an I-MR chart (Source: Overview for I-MR Chart - Minitab)

- ***X bar - R Chart***

X bar - R charts (Average – Range) are used for the statistical process control of small subgroups (subgroup size does not have to be constant) of continuous data, which do not have to be normally distributed. X bar – R chart is a combination of two charts as shown in **Figure 2.32**. The X bar chart shows a time series plot of the averages of subgroup with their control limits. The control limits reflect the variation in the averages of subgroups. The R chart depicts the range of the data that is within each subgroup, revealing changes in variation.

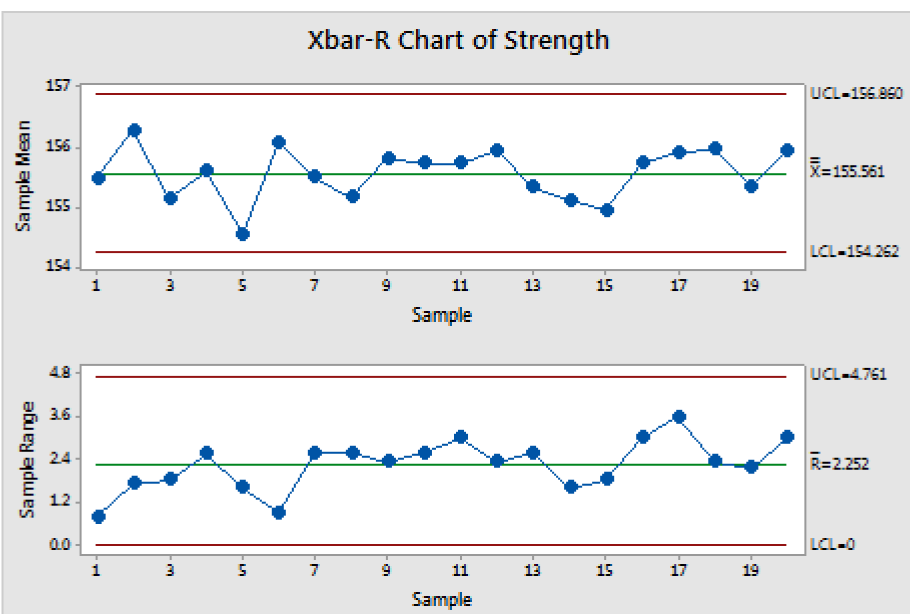


Figure 2.30. Example of an X bar-R chart (Source: Overview for Xbar-R Chart - Minitab)

- ***Laney U' and P' Charts***

Laney U' and P' charts are used for the statistical control of the data that are count or attribute, respectively, are large in size and are separated into subgroups. The Laney U' chart, shown in **Figure 2.34**, is time series plot of the average of the DPU (Defects per Unit) for each subgroup. The control limits represented with the red line may vary for each subgroup as well as the subgroup size. The middle line is the overall average DPU. The Laney P' chart, as shown in **Figure 2.35**, presents a time series plot of the proportion for each subgroup. The subgroup size may vary, and this is reflected in the different control limits. The middle line is the overall proportion of the measured metric.

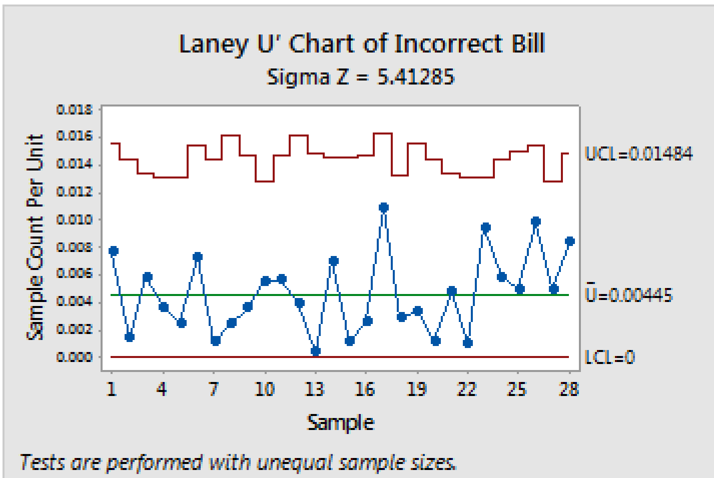


Figure 2.31. Example of a Laney U' chart (Source: laney u chart - Αναζήτηση Google)

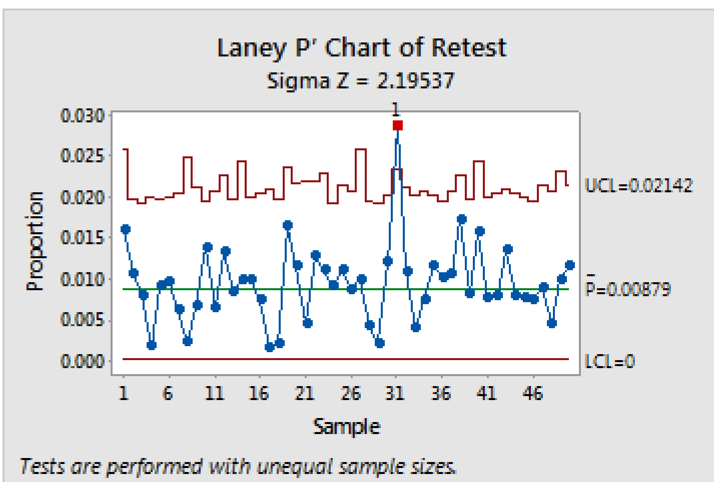


Figure 2.32. Example of a Laney P' chart (Source: Overview for Laney P' Chart - Minitab)

2.1.3 Definition of Retail Supply Chain

A Supply Chain (SC) is the entire network of activities of a firm which link suppliers, warehouses, factories, stores, and customers. These activities include, apart from material flow, services, information, and funds (Nahmias 2009). Supply Chain Management (SCM) is the integration of the processes and the optimization of the efforts of all members of the chain to improve material flow, quality, responsiveness, pricing, add more value to customers, and reduce materials costs (Kannan and Tan 2005; Chan and Chan 2006). A retail supply chain differs from a manufacturer supply chain due to several key factors (Ge et al., 2019). Firstly, retailers cooperate with significantly more partners. A largescale retailer could have tens of thousands of vendors for supplying compared to a smaller and much more manageable number for the manufactures. As a consequence, the retail supply chain should have the ability to operate efficiently and focus more on the coordination of the supply chain. Secondly, relative to a small number of wholesalers for manufacturers, retailers face end customers in the hundreds of millions. In order to plan and adjust properly, retailers have to invest more in comprehending customer demand. Thirdly, there is a difference between the cost structure of a retailer and a manufacturer. Inventory cost covers the majority of a retailer's costs, while a manufacturer spends considerably more on equipment and product lines. Therefore, for retailers, inventory management is much more significant. Consequently, it is crucial for the retail sector to utilise a methodology to improve supply chain business processes and make them more efficient as supply chain management constitutes the core business of retailers. Lean Six Sigma can play the role of this improvement methodology.

The typical SC of the retail sector conists of four main components, as shown in **Figure 2.1**, the Wholesaler, the Distribution Center (DC) of the retailer, the Stores of retailer and the final Customer.

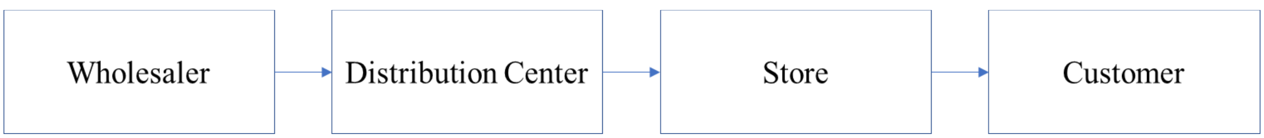


Figure 2.33. Traditional retail supply chain (adapted from Ge et al., 2019)

The more contemporary approach of retail SC includes more levels of relationships among stakeholders and more echelons (stages of merchandise transportation), building a multi-echelon SC. For example, the existence of a Regional DC and a Front DC along with the relationships of merchandise transportation that are developed among the participants of the supply network (manufacturers, wholesalers, DCs, stores, customers) are presented in **Figure 2.2**. Retailers now have more options to meet their consumers' demand (e.g. from stores, warehouses, or directly from the suppliers, etc.), in addition to expanding their warehouse and store network. Moreover, by introducing store brands or private labels, more and more retailers are developing a deeper integration with manufactures and even raw material suppliers (Chen 2018a, b). (Ge et al., 2019)

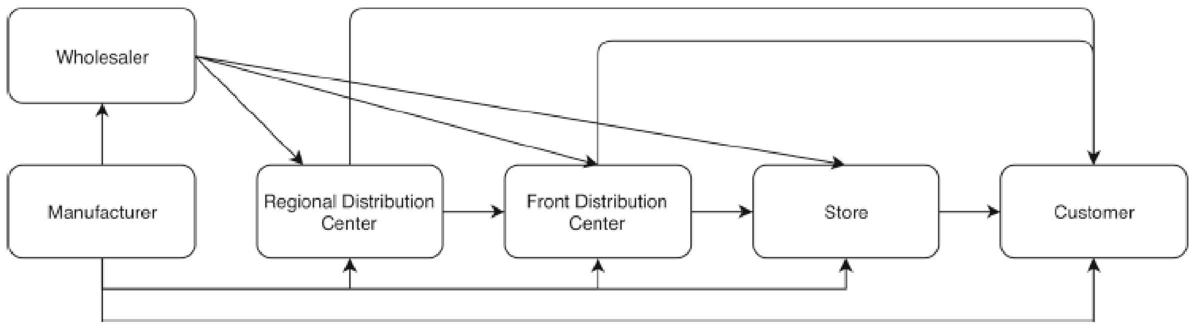


Figure 2.34. Contemporary retail supply chain with more complex relations (Source: Ge et al., 2019)

2.2 Literature Review

The literature review aims to build the pillars of the proposed reference model. First of all, it recognizes the LSS benefits and the Critical Success Factor (CSFs) in order to achieve them. It also presents the papers that study the implementation of LSS in retail supply chain, and supply chain in general, taking the notion of lean supply chain as the starting point of research. The review of the literature continues with the publications that explicitly present reference models, frameworks, or conceptual models regarding the supply chain with or without the implementation of LSS. For all these reviews regarding LSS, an emphasis was given to the papers that included the integrated framework of LSS, as this is the main interest of this study, even though there are several references of papers regarding the separate implementation of lean or six sigma in order to understand the roots of the integrated methodology. The combination of these reviews led to the reveal of the research gap and ultimately to the motivation of this dissertation. The final section of this chapter includes a review of the technological trends concerning the retail supply chain in order to define the technological solutions that are appropriate to be proposed in the developing model, after the recognition of its need. The recording of the modern technological solutions in retail supply chain was conducted with the utilization of 8 textbooks and 39 papers, based on five operational categories- Forecasting, Warehousing, Distribution, Stores, Relationships with Suppliers.

Except for the LSS benefits and the LSS CSFs which were extracted from specific literature review papers, the recognition of LSS implementation in the supply chain and the recording of the models that have been published in the literature were conducted in a systematic way. In particular, for the examination of LSS implementation in the supply chain, the terms “lean six sigma supply chain”, “lean supply chain”, “six sigma supply chain”, “LSS supply chain” were searched in five major publishers (Emerald, Elsevier, Taylor and Francis, Springer, IEEE) and 453 papers were found from 2007 until November 2021 which had as central topic (without being analyzed with another methodology) the application of lean, six sigma or LSS in the supply chain. From them, 27 were kept as they concerned the lean supply chain and LSS implementation in supply chain. These 27 papers include all the papers (found in the selected publishers) concerning LSS implementation in supply chain, and 12 papers regarding lean supply chain which are presented with the purpose to show the evolution of the topic until the appearance of LSS.

For the searching of the models that have been published in the literature concerning retail supply chain, the same publishers were searched, and the keywords that were used were “retail supply chain model”, “retail supply chain reference model”, “retail supply chain conceptual model”, “retail supply chain framework”, “retail supply chain process model”, “retail supply chain process reference model”, “retail supply chain process conceptual model”, “retail supply chain process framework”. The first result was found in 1997 and the search was conducted until November 2021. The result was that from the 339 papers that were detected to concern models or frameworks in supply chain, 29 papers were kept, as the criteria for the selection of papers were to present or include business processes or to completely examine specific processes of supply chain, and especially the retail supply chain. The same keywords were used in the same publishers both with and without the usage of “retail” and “supply chain”, and with the addition of “lean six sigma”, “LSS” words, for the detection of the frameworks/conceptual models/reference models that have been proposed in the literature about LSS in different sectors and about LSS and supply chain combination. From 2005 until November 2021, 113 papers were found that were directly concerned with the searched topic, from which 28 were kept, as they presented structured generalized frameworks or conceptual models about integrated LSS methodology and not just an implementation of a specific framework for a specific case study.

In sum, the methodology that was followed for all the scientific areas included in this dissertation for the systematic analysis of publications is presented in **Figure 2.35.** The first phase of the review is the main factor which led to its composition, namely the identification of the need for such a comprehensive analysis of the literature. The second phase of the method includes the organization of all the research strategy. The third phase encompasses the inclusion and exclusion criteria of the papers that where searched. The fourth and the fifth phase include the data extraction and data analysis and in the sixth phase the results and conclusions of the whole review are extracted.

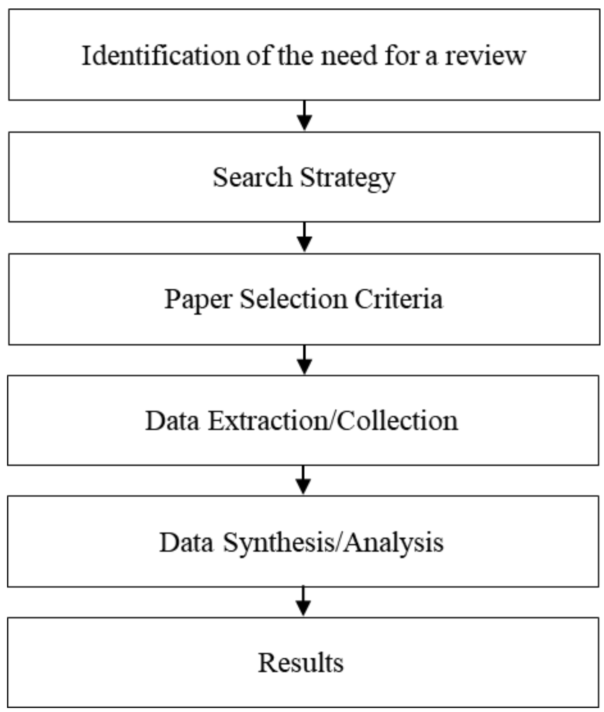


Figure 2.35. Literature Review Methodology

2.2.1 Review of LSS Benefits, Critical Success Factors (CSFs) and Implementation of LSS in Supply Chain

2.2.1.1 <u>LSS Benefits</u>

The analysis of the literature by Albliwi et al. (2015), Raja Sreedharan and Raju (2016), Singh and Rathi (2019) Panayiotou and Stergiou (2021) revealed the benefits that authors point out as an outcome of LSS implementation in European organizations of all sectors. The main benefits referred in the studied papers can be summarized in:

- **Increased savings,** as a general outcome of the application of LSS principles in improvement projects.
- **Reduced costs,** since LSS decreases the need for high level of available stock and helps to improve inventory management. It also reduces the energy costs and the costs of downtimes.
- **Increased revenue,** resulting from improved customer satisfaction and more customers that purchase the product or the service of organizations.
- **Improved process (throughput, lead and waiting) times,** raising the speed of the services offered to the customer or the production operations.
- **Rise of productivity** owing to successful process transformation.
- **Improved product/ service quality,** due to improved standards set by LSS that lead to increased customer satisfaction.
- **Reduced waste,** owing to the improved performance of the redesigned process according to LSS principles.
- **Reduced errors,** because the processes follow stricter specifications and the activities are designed in a simpler manner.
- **Improved business decision-making,** resulting from better process reviewing and controlling using LSS tools.
- **Increased employees' involvement** in the Continuous Improvement initiatives of the organization.

Specific cases of LSS implementation benefits reporting monetary results have been contributed by some authors. De Koning et al. (2008) in a financial organization which reduced the costs by 440.000€ per annum and achieved a rate of 8%-12% less errors. Antony et al. (2017) refer that in a LSS case in UK public sector the achievements were quantified to £290.000 cost savings and 25% less production time. Chaplin and O'Rourke (2018) conducted a study in LSS implementation in the manufacturing sector and underlined that savings reached £280.000 and the process capacity increases about 10%. Hence, through cases coming from different sectors substantial improvement is reported in practice after the implementation of LSS initiatives.

The above benefits resulting from LSS implementation in business process contributes to the improvement of value for money perception of customers, as stated by Lokkerbol et al. (2012), leading to a more functional macro-economic operation.

2.2.1.2 LSS Implementation Critical Success Factors (CSFs)

For the successful implementation of LSS and the attainment of benefits certain CSFs should be fulfilled. The most important factors, recognized by Panayiotou and Stergiou (2021) in their review concerning the LSS adoption in European organization, are: the existence of appropriate culture (24/58), management involvement (21/58), adequate training in LSS concepts and methods for employees (20/58) and harmonization of LSS initiatives with existing strategic goals (17/58). The common denominator in the above seems to be the need for developing the appropriate culture that can permit the management include LSS in the strategic agenda and introduce its concepts in the organization by providing adequate training to the employees, not only in order to attain Belt certifications but also to assure that LSS mentality is spread to everyone in the organization. Therefore, the cultivation of LSS mentality at all levels should be the primary goal in order to adopt LSS principles and take advantage of LSS initiatives in organizations (Panayiotou and Stergiou, 2021, Panayiotou, Stergiou and Panagiotou, 2021; Patel and Patel, 2021; Panayiotou, Stergiou and Chronopoulos, 2020)**.**

Any LSS project success depends on many organizational and leadership aspects that act as essential ingredients. Formal management involvement mechanisms, appropriate project selection, project review, goal setting, training, cultural transformation, understanding the methodology and tools, product/process design and improvement and linking LSS to business strategy and customers are considered to be crucial (CSFs) for the successful LSS implementation (Walter and Paladini, 2019; Tlapa et al., 2016; Khawar et al., 2016; Aldowaisan et al., 2015; Abu Bakar et al., 2015; Antony, 2014; Sabry, 2014). A cultural perspective of LSS CSFs for manufacturing sector was introduced by Geier (2011), who stated that team reinvigoration with employees' involvement and simpler flexible use of LSS guarantee implementation success. Apart from the CSFs which play a key role in LSS implementation, the creation of a standardized toolset following DMAIC phases could help organizations, adopt and execute LSS initiatives in an easier manner (Panayiotou and Stergiou, 2021). This facilitation could increase the number of manufacturing companies that decide to apply LSS techniques in order to improve their processes and be benefited from the improvements.

2.2.1.3 LSS implementation review in supply chain

According to Albliwi et al. (2015) supply chain is one of the core functions that are benefited by LSS. This inference is endorsed by Andersson and Pardillo-Baez (2019) who found, conducting a research among companies that have adopted LSS, that supply chain risk management is facilitated and improved through LSS, and propose the diffusion of LSS methodology throughout the supply chain for its adoption by all stakeholders (suppliers, retailers, distributors). Thus, the principles of LSS can be utilised in SCM to ensure customer satisfaction and efficiency in the flow throughout the supply chain (Salah and Rahim, 2019).

The notion of Lean has been combined with supply chain in several concepts and has been implemented in various sectors. There are many publications which refer to the benefits of the Lean Supply Chain Management (LSCM) that is defined by Christopher (2000) as "eliminating all kinds of waste in internal processes and in the relationships between a firm's customers and suppliers". Cost Reduction (Qi, Zhao, and Sheu, 2011; Qi et al., 2017), reduction of lead times, and inventory minimization (Vonderembse et al., 2006) are the main benefits that are stated in the literature. The integration of Lean principles in supply chains has been studied in different sectors. In the manufacturing sector, the emphasis is given on the implementation of Lean for inventory management improvement (Marodin et al, 2016; Ghosh, 2012; Pianizzolo et al., 2012; Eroglu and Hofer, 2011). In addition, the implementation of lean and green in the supply chain automotive industry was studied by Duarte and Cruz Machado (2017) in an automotive industry, and in Indian manufacturing firms by Gaikwad and Sunnapwar (2021) as LGSS (Lean Green Six Sigma) framework. The integrated framework of LSS has been mainly used in the supply chain operation of manufacturing companies, such as the study of Garza-Reyes et al. (2016) examining the improvement of ship loading commercial time utilizing LSS DMAIC in a heavy industry of iron ore production. Samsung is another instance of successful implementation of LSS in improving its inventory visibility and management, too (Yang et al., 2007). The analysis and improvement of the production of an aerospace company as part of its supply chain through LSS is one more case examined by Thomas et al. (2016). More recently, Chiarini and Kumar (2020) identify the need for the integration of Industry 4.0 principles and LSS for achieving Operational Excellence in the flow of the productive supply chain of manufacturing companies. A recent penetration of LSS in the supply chain of maritime industry is revealed by the literature through the application of LSS in the supply chain of a shipbuilding company that is examined in terms of its resilience by Praharsi et al. (2021). Apart from the manufacturing sector where the interest concentrates on the processes concerning the supply chain of production, in the food sector Vlachos (2015) analyzes the lean adoption by the supply chain of a tea industry. There are also publications in services sector, such as this by Al-Aomar and Hussain (2018) who assess the adoption of Lean techniques in a hotel supply chain and studies about LSCM in the healthcare sector (Khorasani et al., 2020; Marzouq Almutairi et al., 2020). The implementation of LSS in the supply chain of a telecom company is also examined for the improvement of the mobile order fulfilment process (Shamsuzzaman et al., 2018). In the aviation services, the implementation of LSS in an MRO (Maintenance, Repair, Overhaul) facility is studied by Hill et al. (2018) for the enhancement of its operational performance. The Six Sigma methodology has been individually implemented in the supply chain of trading organizations in order to cope with operating problems and improve their performance (Kandil and El Aziz, 2018).

The implementation of LSS in Logistics services has been studied through a case study by Gutierrez-Gutierrez et al. (2016) concluding in improvement of service level quality and reductions in flow times. There are a few studies about LSS implementation in supply chains of retail companies or organizations with activities solely in distribution and selling of merchandise. An example of such a study has been published by Nabhani and Shokri (2009) concerning the reduction of lead time in a food distribution SME using LSS. As mentioned by Zhang et al. (2016), only 22% of companies with core business in the Logistics sector, such as retail companies that were included in the research, were implementing LSS initiatives. The adoption of Lean in Logistics and Supply chain has also been studied in terms of reduction of cost and time of transportation, and warehousing through strategies such as VMI, cross-docking, third-party logistics, supplier parks, and distribution centers (Mishra, Kumar, and Garg, 2015; Rivera et al., 2007; Stavrulaki and Davis, 2010).

2.2.2 Review of Reference Models/Frameworks

2.2.2.1 Reference Models/Frameworks of Supply Chain

The Supply-Chain Operations Reference (SCOR) model is the first and the most popular process reference model in the SCM domain (Stewart, 1997), presenting a high level of supply chain organization and acting as a guide for the configuration of supply chain processes. It was developed by the Supply Chain Council's experts and practitioners and is a comprehensive framework for supply chain planning, featuring SCM processes and Business Process Reengineering (BPR) (Stephens, 2001; Lockamy III and McCormack, 2004a). SCOR is introduced as a standard SCM configuration diagnostic tool. The SCOR model draws on the principles of process reengineering, performance measurement, as well as logistics management (Huang, Sheoran, and Wang, 2004). These concepts are incorporated into a configurable and cross-functional framework consisting of business processes, metrics, best practices, and proposed actions that can be used to describe the supply chains and the communication between them as a common language for organizations (Lambert, García-Dastugue, and Croxton, 2005). While it is an integrative guide with many merits, it only offers a 'top-down' approach that calls for the comparative analyses of pre- and post-performance indices as a basis for the business process modification. Nonetheless, SCOR implementations are diversified in various areas, such as manufacturing (Li, Su, and Chen, 2011; Kottala and Herbert, 2019), public utility companies, tourism industry, transportation, and services supply chain (Li, Su, and Chen 2011). Further expansion of SCOR to supply chain is proposed by frameworks developed for the business processes of supply chain (Ahoa et al. 2018; Girjatovics et al., 2018). In addition, Bilińska-Reformat et al. (2018) develop a model combining SCOR sustainability and Ayyildiz and Gumus (2021) propose an extension of SCOR model to follow Industry 4.0 principles.

There are several other SCM-related reference models, such as the SCM maturity model (Lockamy III and McCormack, 2004b), the Collaborative Planning, Forecasting and Replenishment (CPFR) model (Seifert 2004) and an extended model of CPFR (Wang and Xu, 2014), and the Agent-Based Systems Reference Model (ABSRM) (Modi et al., 2006). The SCM maturity model suggests that progress towards achieving goals takes place in five stages, and the model helps managers identify areas of progress and stagnation. By looking at several areas, such as integration, cooperation, collaboration, organization structure, strategy, measurement systems, best practices and customer focus, the model expands the value and effectiveness of the SCOR model. The CPFR model (Seifert, 2004) focuses on improving supply-chain integration through cooperation, supporting, and assisting joint practices. Since the mid-1990s, various well-known organizations, including Wal-Mart, GSK and Heineken, have adopted the CPFR model. Plenty of organizations that build and deploy systems based on agent technology have also adopted the ABSRM (Modi et al., 2006). Agent-based systems are able to efficiently and effectively manage different supply chain activities (Mishra, Kumar, and Chan, 2010). Therefore, ABSRM is highly important to organizations since it serves as a base for situating the complete range of functions that someone would want or need to have in an agent-based system (Modi et al., 2006). A more recent model has been suggested by Haas (2019) who presents a generic retail business model framework (generic RBM). A set of suggested models are included in process-oriented supply chain models, containing the Global Supply Chain Forum framework (GSCF) specialized in logistics (Marchesini and Alcantara, 2016), the Process Classification Framework for healthcare operations (PCF) (Mantje et al., 2016), and the model described by Bremer (2018) for cold chains. Moreover, in sectoral level the fashion retail supply chain appears to have been studied by the models of Iannone et al. (2015) and Martino et al. (2017).

Several conceptual models have also been proposed, examining the contribution of RFID (Radio Frequency Identification) in retail supply chain (Garrido Azevedo and Carvalho, 2012; Bhattacharya, 2015). Conceptual models for the measurement of the retail supply chain performance are proposed by Mishra and Ansari (2013) and, more recently, by Adivara et al. (2019) for omnichannel retail supply chains. The more recent trends appear in the models by Teller et al. (2016), concerning the collaboration and relationships with suppliers, and an emphasis on forecasting is given by the model of Punia et al. (2020). Furthermore, the proposal of a framework for the resilience of the supply chain was developed by Alikhani et al. (2021).

2.2.2.2 Reference Models/Frameworks incorporating Lean Six Sigma

As concerns LSS, there are several frameworks that have been proposed in the literature which act as guides of LSS implementation in various sectors. For example, Thomas et al. (2008) give an overview of how LSS can be implemented in manufacturing companies and suggest tools that can be used in the DMAIC method. Similar studies for the manufacturing sector have been conducted by Gibbons and Burgess (2010) and Wang et al. (2011) aiming at the elimination of non-value-added activities and lean product development, respectively. In addition, Jeyaraman and Kee Teo (2010) have developed a conceptual framework for CSFs of LSS for the manufacturing sector. In financial and banking services, there are also proposed frameworks including tools and techniques that can be used in order to implement LSS or select suitable LSS projects (De Koning et al., 2008; Bortolotti and Romano, 2012; Hsieh et al.. 2012; Chakraborty and Leyer, 2013). In the construction industry, a comprehensive framework of LSS implementation has been proposed by Al-Aomar (2012), and a framework of LSS implementation in enhancing quality excellence in higher education institutions is proposed by Sunder and Antony (2018).

As concerns LSS and SCM, there are various studies proposing frameworks/ conceptual models for their combination. General models and frameworks for Six Sigma or LSS application in supply chain have been developed by Knowles et al. (2005), Mazzola et al. (2007), Lee (2010) and Salah et al. (2011). In addition, a supply chain model focusing on the integration of LSS and logistics operation was developed by Rahman and Rahman (2012). Mishra and Kumar Sharma (2014) suggest a framework which proposes the implementation of DMAIC in supply chain networks, and Mishra and Kumar Sharma (2015) developed a conceptual model utilizing LSS for supply chain coordination. Guiffrida et al. (2017) incorporates LSS and supply chain in a framework, aiming at the improvement of deliveries. A more specific framework about how RFID technology can be combined with Six Sigma in the supply chain is described by Zare Mehrjerdi (2013). Enabling technologies, like Internet of Things and Industry 4.0, are proposed to be implemented along with LSS by Jayaram (2016) in a model for global SCM. In addition, Tay and Loh (2021) proposed a conceptual framework for the improvement of supply chain by enabling digital transformation, through

DMAIC problem-solving approach. Sectoral frameworks have been also developed regarding LSS and its implementation in the manufacturing supply chain (Davilia et al., 2019), in the food industry supply chain (Message Costa et al., 2021), and in the food supply chain with expansions of sustainability (Adeborode Kolawole, 2021). Sustainability and LSS notions have been integrated as well, in a model developed by Sreedharan et al. (2018) for the public sector. Furthermore, a framework for the implementation of lean in healthcare supply chain has been suggested by Marzouq Almutairi et al. (2020).

As concerns the retail sector, there are three publications by Madhani (2020a, 2020b, 2021) developing a framework for the implementation of LSS in the retail supply chain. All these conceptual models or frameworks, however, are not representing reference models, but frameworks of LSS implementation under specific circumstances. For that reason, in this dissertation a reference model following a holistic approach by presenting the whole retail supply chain in the form of modeled processes and proposing how LSS methodology can be implemented in specific activities of these processes is developed.

2.2.3 Motivation of the Research and Research Gap

Based on the literature, the benefits that can be attained by the adoption of LSS in the supply chain processes of all sectors are several and substantial. However, there is not a shared proportion of publications about LSS in all sectors. For this reason, the need for publications in more sectors, apart from manufacturing, is highlighted by Sreedharan and Raju (2016), Yadav and Desai (2016), Singh and Rathi (2019), and Panayiotou and Stergiou (2021). In addition to that, there is a prompt by the literature for the development of models or frameworks incorporating LSS, in the not studied sectors, for the facilitation of its implementation by practitioners (Sreedharan and Raju, 2016; Raval and Kant, 2017, Raval et al., 2020, Patel and Patel, 2021).

The literature also recognizes the contribution of LSS initiatives to the supply chain processes of companies operating in the retail sector through their simplification, substantial cost reduction, and improved inventory management and replenishment models (Martin, 2014; Madhani, 2020a, 2021). Having in mind the importance of the supply chain in the operation of companies of the retail sector, a large number of publications about LSS adoption in retail supply chains was expected. However, the analysis of the literature concerning the implementation of LSS in the retail sector and, particularly in supply chain processes, revealed that there is a gap in this specific area. This statement is supported by Lameijer et al. (2016) who analyzed the projects respectively concerning LSS until 2015, and the retail sector was last with three projects over 312. More recently, the same pattern is presented by Panayiotou and Stergiou (2021) who found, by conducting a literature review about LSS implementation in European organizations as a representative sample of LSS trends around the world, that there was only one publication about LSS in Retail and one about LSS and Logistics and Supply chain of the total number of 88 cases. In the same publication there is a prompt for more studies about LSS implementation in retail sector and the integration of new technologies (Industry 4.0 and automations) with LSS initiatives. The latter is a proposal presented in more recent studies as it is considered of high importance in supporting CI (Sony, 2020; Puram and Gurumurthy, 2021) and supply chain operation and improvement (Chiarini and Kumar, 2020).

Furthermore, the reference models that have been developed to describe the supply chain function are either not completely dedicated to the retail sector or just include a sub-set of retail supply chain processes. Additionally, Odintsova et al. (2018) highlight the need for the development of more retail SCM models. That is why a framework integrating the modeling of a wider view of retail supply chain processes and the guidance of LSS implementation in them can constitute a reference model with a high value in retail sector improvement initiatives. In this dissertation, the gap that exists in the literature concerning LSS implementation in retail supply chain is managed to be filled through the development of a supply chain process model incorporating emerging technologies and contemporary business requirements.

The assertion that the LSS should be more widely adopted by the retail sector is supported by the fact that according to the International Finance Corporation (IFC) retail employees account for 10 to 15 percent of the job market worldwide. In addition, an analysis by Deloitte (2020) reveals that the retail sector has grown about five percent from 2013 to 2018 and the contribution of retail sector in US GDP, according to the Bureau of Economic Analysis (2019), was around six percent. These facts reveal the significance of the retail sector in the world economy and society and indicate the need for improvement initiatives in the sector in order to ensure the consistency of its operations efficiency.

An explanation of the poor implementation of LSS in the supply chains of the retail sector is the barriers that generally exist in the adoption of LSS and CI mentality. The adoption of LSS in the supply chain of all sectors is prevented by barriers that should be confronted as stated by Mithun Ali et al. (2020). Except for the lack of executive management involvement (Albliwi et al., 2014; Rodríguez, P´erez, and Guti´errez, 2008), lack of training (Chan, Ismail, Ahmad, Zaman, and Lim, 2019), lack of LSS knowledge (Albliwi et al., 2014) and resistance to change (Oreg and Berson, 2009; Shokri et al., 2014; Zhang et al., 2016), there are also four main barriers influencing the implementation of LSS in the supply chain. The existence of problems in information sharing and flow within processes and stakeholders (Hussain et al., 2019; Jadhav et al., 2014) is one of the main barriers. In addition, slow response to competitive market changes (Jadhav et al., 2014), as managers may not have the tools and the full view of processes to improve them in order to respond to market pressures, is an obstacle for LSS adoption. Lack of planning in the organizational level (Dahlgaard & Mi Dahlgaard-Park, 2006; Snee, 2010) and technological barriers are the last but not least impediments as the non-existence of organized processes, and emerging and contemporary technologies in operations of supply chain act as inhibitors in its improvement and in LSS adoption. The developed reference model of this dissertation attempts to cover the recognized research gap and overcome the barriers by answering the following Research Questions (RQ):

RQ1: What retail supply chain activities are eligible to be improved with the help of LSS methodology?

RQ2: How can LSS contribute to the improvement of retail supply chain processes?

It also tries to limit the existing barriers in the adoption of LSS in the supply chain processes of the retail sector. This reference model can be a guide for the supply chain operation and the facilitation of LSS adoption by highlighting areas of improvement in specific processes, suggesting specific LSS initiatives and proposing a toolset for their implementation.

2.2.4 Review of Technological Solutions in Retail Supply Chain

2.2.4.1 Forecasting

Demand forecasting is essential for a retail company’s success. An accurate and practical demand forecasting system, particularly in supply chain management, can be a substantial source of competitive advantage by improving customer service levels and lowering costs associated with supply-demand mismatches (Snyder and Shen 2011). Consequently, the forecasting problem has a long history of research in statistics, as well as more recently in machine learning. Demand forecasting is a practical domain of time series modeling and forecasting (Hamilton 1995). Many significant models for enhancing the accuracy and efficiency of time series modeling and forecasting have been proposed in the literature.

The most widely used methods in demand forecasting are stochastic time series models. There are two primary classes of stochastic time series models: linear and non-linear models. Two of the most extensively used stochastic time series approaches, i.e. the Holt-Winters method (Holt 2004; Winters 1960) and the

Autoregressive Integrated Moving Average (ARIMA) model (Box et al. 2015), are included in the linear model. The Autoregressive (AR), Moving Average (MA), Autoregressive Moving Average (ARMA), and Seasonal ARIMA (SARIMA) models are all subclasses of the ARIMA model (Hamzacebi 2008). These models are unsuccessful at modeling highly nonlinear time series, despite their ability to capture trend and seasonality. Several non-linear stochastic models, such as the Autoregressive Conditional Heteroskedasticity (ARCH) (Engle 1982) and Generalized ARCH (GARCH) (Bollerslev 1986) models, have been proposed in the literature to overcome this disadvantage; nevertheless, the implementations are not as simple and straightforward as in the linear models.

Machine learning techniques such as Decision Tree (Breiman 2017), K-Nearest Neighbor Regression (KNN) (Hastie and Tibshirani 1996), Support Vector Regression (SVR) (Drucker et al. 1997), and Gaussian Processes (GP) (Williams and Rasmussen 1996) have been broadly used in the field of forecasting over the last few decades. Machine learning methods are more data-driven than stochastic time-series models, which are more model-driven; generally, these machine learning methods are employed to enhance time series predictions by minimizing a loss function. Ahmed et al. (2010) correlates the accuracy and time consumption of these machine learning models. Zheng and Su (2014) introduced a two-step improved KNN technique that consistently increased the forecasting accuracy in short-term forecasting. Two well-known SVR models for time series forecasting are recurrent least-square SVR (Suykens and Vandewalle 2000) and dynamic least-square SVR (Fan et al. 2006). Girard et al. (2003) suggested using the non-parametric Gaussian process model for multi-step ahead time series prediction in order to integrate the uncertainty about intermediate regressor values, allowing the uncertainty on the current prediction to be revised. Decision Tree provides a foundation for numerous tree-based ensemble algorithms with Random Forest (Kam 1995) and Gradient Boosting Decision Trees (GBDT) (Chen and Guestrin 2016; Ke et al. 2017; Prokhorenkova et al. 2017) being two of the most extensively used machine learning approaches. The Random Forest model has been used for electricity load forecasting (Nedellec et al. 2014; Dudek 2015), and it has been proven that its forecasts are as accurate as artificial neural networks (ANN) and that it surpasses ARIMA and Decision Tree models (Dudek 2015). It has been demonstrated that Random Forest is capable of one-step-ahead time series forecasting, and that a low number of recent lagged variables performs better, emphasizing the importance of the training set's length (Tyralis and Papacharalampous 2017). GBDT, like Random Forest, has shown adequate performance in time series forecasting when compared to other stochastic time series and machine learning methods (Kusiak et al. 2009).

Increased access to data and computational capabilities has improved decision making. As a result, dynamic pricing of goods that is already applied in other services, such as booking airplane tickets, can now be applied in groceries. Dynamic price in groceries can be implemented either by changing prices according to the demand or product quality. For example, with machine learning it is easy to predict demand changes on certain products in hot or rainy days and price them or order them, accordingly. Same thing applies with all the information for the origin, transportation and conditions of the products, which also affect their price. Forecasting can be used to understand consumer preferences and create projections for the demand, too. Artificial Intelligence (AI), cognitive solutions and machine learning models can effectively analyze and use the large amount of data providing accurate and realistic solutions by fully modeling the entire network, analyzing all data from cloud platforms, social network trends and they can provide what if scenarios about potential risks, inventory, and orders (Garay-Rondero et al., 2020; Weber and Schütte, 2019).

2.2.4.2 Warehousing

Warehousing can be broken down in the sub-processes: ordering fulfillment, storage, storage allocation, storage receiving, order picking and truck loading (Ding et al., 2021). Thus, warehousing is an area with plenty potential applications, some of them already used in big retailing companies. Automation in warehouse has many applications reducing labor time, work accidents and improving cost efficiency. One of the automations application concerns loading and unloading activities which can be executed with robotics. Robotic tranporters of products can execute the sorting, packing, storage and picking activities. A simpler method is via smartphone applications or smart glasses guiding personnel and speeding up the processes with the combination of RFID (Radio Frequency Identification), IoT (Internet of Things) sensors, M2M (Machine-to-Machine) technologies.

RFID is another technological application, which involves the incorporation of an electronic microchip within a tag or label that can be subsequently attached to, or embedded in, a physical object which contains uniquely identifying signals, and requires the utilization of reader. This device can be integrated to the IoT system for the exchange of information about merchandise. Benefits associated with the RFID technology are the improved distribution and inventory control within the warehouse, as well as, benefits associated with the retail store environment, where the identification and the recording of products is much more easier and faster through a simple scanning (Sellitto et al., 2007).

Furthermore, wearable devices for employees can boost ergonomics and provide accurate data to further understand vulnerabilities of the processes. In the automation of logistics processes, AR (Augmented Reality) is used to enable man–machine interactions through the integration of real and virtual information by using cameras, smartphones, tablets, AR helmets, and data glasses (Jost et al. 2017). AR is often used to support picking operations. In this context, the pick-by-vision technology can lead to an enhanced picking efficiency (of up to 25%) by simultaneously eliminating almost all picking errors (Deutsche Post AG 2015). This approach was also transferred to packaging operations leading to higher usage of packaging space (up to 19% more) and lower costs (−30%) (Mättig et al. 2016). Wearable devices can not only improve the safety of the employees but also their effectiveness by telling the exact spot of the storage unit and providing hands free guidance and much quicker training (Ding et al., 2021; Garay-Rondero et al., 2020; Vallandingham et al., 2018; Weber and Schütte, 2019).

Consequently, everything in the warehouse can be integrated in an intelligent entity and creates a M2M communication network feeding the WMS (Warehouse Management System) with real-time data, high accuracy and visualization creating strong fundamentals for Replenishment, Ordering and Inventory Management.

One more warehouse application that is found in literature is the temperature, humidity, and light sensors which monitor the storage conditions and then storing and sharing these data to control centers. The conditions can be altered if needed either automatically or with human intervention from the control centers. Furthermore, big data analytics can manipulate these data sets and provide useful intel for the products' quality and help to expand the shelf life of the products. These technologies apart from efficiency they provide standardization of the storage environment and detailed documentation (Ding et al., 2021; Garay-Rondero et al., 2020; Vallandingham et al., 2018).

Finally, the utilization of conveyor belts for the transferring of the products from the storage area to the loading area is also a technological solution which makes the transportation within the warehouse and sorting easier and faster and ensures the safe movement of products (Zsifkovits et al., 2020).

2.2.4.3 Distribution

Transportation and distribution of the products are processes which heavily affect the cost of the supply chain of retailers. In recent years, efforts from various retailing companies managed to reduce these costs associated with the transportation process by incorporating several new technologies. Still, there are many logistic challenges and opportunities for the retailers for further utilization of state-of-the art technologies (Kumar, 2008). By utilizing technologies such as IoT, blockchain, RFID, Big Data analytics, AI (Artificial Intelligence), Machine Learning, GPS, wireless sensors networks and cloud computing, the field of smart logistics accelerated with new capabilities and applications for intelligent transportation and smart freight. Intelligent transportation systems provide better transportation and traffic management empowering the route planning with real-time traffic data, constant monitor, and tracking. Hence trackability, efficacy and optimization are achieved. Simultaneously, these systems increase the utilization of trucks with better planning and make last minute changes less risky. Smart freight includes route tracking, conditions monitoring with sensors and the Electronic Product Code in the RFID. During transportation process real-time information sharing occurs information through cloud computing, shared databases and software to distributors, logistic companies, and retailers. These systems transform the logistics processes to fully traceable processes, minimizing errors, deterioration of perishable products, labor time, discrepancies and guarantees products' quality (Ding et al., 2021; Vallandingham et al., 2018; Weber and Schütte, 2019).

Route optimization algorithms can be implemented into information systems, in addition to all of today's technologies, to export the best feasible itineraries. The employment of models to describe the transport network that has to be developed is the foundation for route optimization (Parkhi et al., 2014). The weight and volume of products, the destinations and their distances from the DC, the attributes of available vehicles for transportation (volume or weight capacity, loading times, cost per mile, vehicle limitations such as speed), the available personnel for loading and delivery, and the transportation cost can all be taken into account by these algorithms (Parkhi et al., 2014). The Turnaround Time (TAT), that is the total time taken by the truck from loading it in the distribution center to delivering to retail stores and returning to the DC for reloading, is another factor that could be counted in the algorithms. Loading time, document verification time, travel time, idle time, and store retention time are all included in the TAT. The truck can be used more, i.e., more delivery schedules, if the turnaround time is reduced. Moreover, resource will be immediately available to the planning department for the next schedule. Back-hauling (where vendors pick up merchandise rather than merely empty pallets and cartons) can also be incorporated into the routing algorithm, as it reduces transportation cost by integrating returns with incoming merchandise (Juan et al., 2014).

2.2.4.4 Stores

In-store experience and service is the last mile of the supermarket supply chain. By optimizing this experience, customers are converted into loyal customers and their purchases are increased (Kumar, 2008). Creating a smart store is a new trend alongside e-retail. Customer interfaces, applications, electronic shelves labels, self-checkout, usage of the smart phones and online delivery services are some implementations of various companies not only for better customer services and data collection, but also for better forecasting and replenishment (Begley et al., 2020; Garay-Rondero et al., 2020; Schütte, 2019). One application is floor sensors identifying and analyzing customers' walking habits, for example how fast the walk in certain aisles, where they stop, and what they avoid. All these data can support better in-store layout. In addition, smart carts with in-cart scanners can provide self-check-out. Smartphone applications with customers profiling, combined with AI, create new capabilities for customers, such as informing them while walking in an aisle for sales, suggesting them items according to items already picked and even helping them create a shopping list for perishable products. For instance, with mobile applications and machine learning, when a customer buys milk, according to previous patterns on how often he/she purchases this item, an automated, ready for submission, list is created. When this list is submitted by the customer, the items can be prepared from the store for pick-up or for delivery. Future usage of the state-of-art technologies can incorporate drones for last mile delivery for customers that prefer online shopping of their daily products. Finally, e-grocery and omni-channel (the integration of both physical and digital channels for offering the best customer experience) strategies is the new trend in retailing and grocery to provide customers with premium customer experience (Cain and Paratore, 2019).

2.2.4.5 Relationships with Suppliers

Inventory reduction can be achieved by implementing initiatives such as information sharing, continuous replenishment program, and VMI (Vendor Managed Inventory), as relevant literature consistently acknowledges. There are numerous streams of relevant literature in the field of these initiatives: literature on (1) interorganizational systems (IOS); (2) quantitative models in information sharing; and (3) information sharing implementation through VMI and CPFR (Collaborative Forecasting, Planning and Replenishment) (Yao and Dresner 2008).

The first stream of research has disclosed the business value of IOS through the examination of supply chain management initiatives, such as information sharing, continuous replenishment programs, and VMI. IOS, as a link between suppliers and buyers, has been proved in research to increase a firm's performance and provide competitive advantages (Sethi et al. 1993; Palmer and Markus 2000; Premkumar 2000; Srinivasan et al. 1994).

The value of information sharing in supply chains has been quantitatively analyzed in the second stream of research. For instance, the aftermath of the bullwhip effect can be lessened via information sharing (Lee et al. 1997; Lee and Whang 1999; Lee et al. 2000; Cachon and Fisher 2000; Chen et al. 2000). According to research, policies like VMI can reduce the bullwhip effect, thus enhancing supply chain efficiency by lowering inventory levels and shortening cycle time (Cachon and Zipkin 1999; Kulp et al. 2004; Mishra and Raghunathan 2004). Simulation is used by Angulo et al. (2004) to discover that demand information sharing is an essential part of VMI implementation and can increase the fill rate by up to 42%. C, etinkaya and Lee (2000) propose an analytical model for using VMI systems to coordinate inventory and transportation decisions. Empirical evidence is presented by Lee and Whang (1999) to support the value of supply chain coordination. Using data from 31 grocery retail chains, these authors show that inventory turns and stock-outs have enhanced after the implementation of continuous replenishment programs.

The third stream of research has focused on the collaboration and integration in the context of supply chains over the last few years, particularly in the area of CPFR. Panahifar et al. (2015) use a devised state-of-the-art taxonomy for the classification of chosen references, related to CPFR, to review the scope and value of CPFR. In this paper, which is based on a total of 93 papers published from 1998 to 2013 on CPFR, the authors attempt to address the question of what are the main constructs and efficient framework for effective implementation of CPFR. The paper's essential finding is that four main constructs for successful CPFR implementation have been established: 1. CPFR enablers; 2. CPFR barriers; 3. trading partner selection; 4. incentive alignment. The finding suggests that a deeper understanding of the amount and level of information sharing as a critical function of CPFR implementation is required. In an efficient and integrated CPFR environment where firms share promotion plans, sales data, and retail analytics, and vendors share inventory and shipment information, the supply chain is more sensitive to external business change and all partners profit from the information sharing.

Furthermore, purchasing merchandise, fulfilling the procurement process, and selecting suppliers are very important and time-consuming processes in the supply chain management, occupying personnel and hiding risks. New technologies can improve this process by making e-procurements and smart contracts feasible. Especially, the blockchain technology enables the smart contracts providing transparency, accuracy and reliability between the stakeholders. An example of smart contracts and e-procurement is that the payment process gets automated and when the contract requirements are met, and the products arrive at the distribution center or the warehouse at the quality and quantity agreed, then the payment is automatically settled. In the case that the quantities changed, or the requirements aren't met, the payment is updated automatically, which means that errors and personnel intervention is reduced, and contracts are executed digitally. At the same time all the participants are aware, and changes are visible, secured and authorized creating digital trust (Ding et al., 2021; Sheel and Nath, 2019; Wang et al., 2019). This transition leads to the development of collaborative platforms among supply chain stakeholders (i.e., manufacturers, vendors, retailers) for the sharing of information and the decision-making for merchandising agreements, as shown in **Figure 2.3**, regarding the products of each vendor and the existing needs of replenishment based on stock and on specific forecasting factors. The adoption of web-based tools in the procurement process allows organizations to either reduce transaction costs or improve internal procurement process efficiency, or even increase collaboration with vendors (Nicoletti, 2013). Blockchain allows all trading parts to share documents, transactions data in a fast and secure way providing standardized and high-quality documentation (Sheel and Nath, 2019).

Finally, in the supplier selection process, AI and machine learning allows the organization to improve decision-making with real-time data, taking into account different factors and not only prices. For example, after considering weather conditions and perishable products origin and life cycle the supplier with the best product quality can be recommended (Irfan and Wang, 2019; Weber and Schütte, 2019).

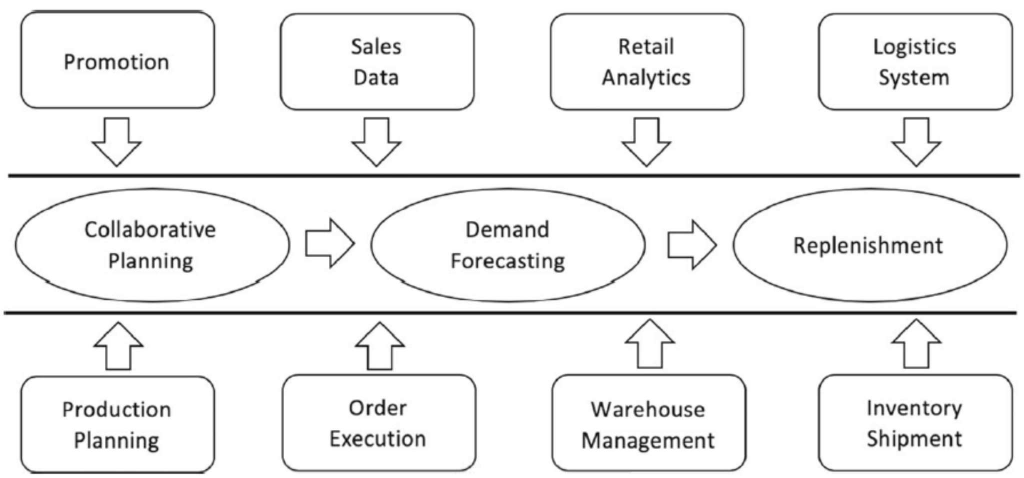


Figure 2.36. Collaboration in the retail supply chain (Source: Ge et al., 2019)

3 Research Methodology

3.1 Research Methodology Theory

3.1.1 Research Design

Research designs are plans and procedures for research that cover all decisions, from broad assumptions to detailed data collection and analysis methods. (Creswell, 2007) The ultimate decision entails choosing which design should be employed to study a topic. This decision should be based on the assumptions the researcher brings to the study; procedures of inquiry (called strategies); and specific methods of data collection, interpretation, and analysis. The nature of the research problem or issue being addressed, the researchers' personal experiences, and the study's target audiences all play a significant role in selecting a research design.

There are three types of research design, qualitative, quantitative, and mixed methods research:

- ***Qualitative research*** explores and comprehends the meaning that individuals or groups attach to a problem. Emerging questions and procedures are part of the research process, as are data collected in the participant's setting, data analysis that builds inductively from specific to general themes, and the researcher's interpretations of the data. The structure of the final written report is flexible. Those who engage in this type of inquiry promote an approach to research that values an inductive style, an emphasis on individual meaning, and the significance of rendering a situation's complexity (adapted from Creswell, 2007).

- ***Quantitative research*** examines the relationship among variables in order to test objective theories. These variables can then be measured, mainly on instruments, in order to be able to analyze numbered data using statistical procedures. Introduction, literature and theory, methods, results, and discussion are all part of the set structure in the final written report (Creswell, 2008). Those who engage in this form of research, like qualitative researchers, have assumptions regarding testing theories deductively, building in protections against bias, controlling for alternative explanations, and being able to generalize and replicate the findings.

- ***Mixed methods research*** is an approach that integrates or links both qualitative and quantitative forms. It includes philosophical assumptions, the application of qualitative and quantitative methods, and the combination of the two in a study**.** As a result, it involves more than just gathering and analyzing both types of data; it also uses both methodologies in tandem, so that a study's overall strength is greater than either qualitative or quantitative research (Creswell & Plano Clark, 2007).

3.1.2 Research Paradigm

The main research paradigm categories are the following (Jonker and Pennink, 2010; Creswell, 2009; Neilimo and Nasi, 1990):

- ***Positivism***

The goal of applied research is to find solutions to problems that arise in practice. Researchers focus on developing (re)designs and action plans to tackle these problems. Their approach is built on the idea that (scientific) action leads to useful concepts. During their studies, most researchers are trained to deal with these problems using a three-step approach: diagnosis, design, and change. At first, establish a clear problem definition, then design a solution, and finally put it into action. This frequently leads to the creation and implementation of a variety of instruments and techniques: organizational 'recipes' that have to be properly combined in order to achieve the desired effect. A crucial condition is that the people involved in the research use these tools themselves. The fact that this approach often appears to fail (or only to a limited extent) in practice can be related to people's reluctance to change and the course alterations that occur throughout the implementation of the desired changes. Nonetheless, the researcher can assert his innocence since he conducted the project in a methodologically proper way. Using his expertise, the researcher determines the optimum form of research for a certain situation. The solutions are based on facts gathered via means of research he 'scientifically' justifies. It should be noted that, in several cases, books in the field of business research that focus primarily on methodology fail to include implementation as part of the research. **Positivism** is the name given to this description.

- ***Constructivism***

Applied research is conducted in an organization's complex environment. Everything is happening and changing at the same time: people, systems, procedures, processes, designs, culture, attitudes, behavior, rules, and politics. Everything is true, or at least valid, which leads to several problems. Anyone attempting to investigate, let alone alter, an organization will discover that each group of people, each department, or each location has its own characteristics, rules, and habits. This is the reason why we confront a unique problem each time, one that can be understood and solved only by reflecting on knowledge and experience collected throughout the course of the research inside the organization. Employees involved in research need to continually reconstruct their own reality and alter it in order to adapt to the situation and developments. There are no universal approaches, designs, or concepts. They can, at best, assist in the development of a guiding notion to frame a situation. Observing reality from the outside rarely yields new insights into the current state of affairs. True insight necessitates reaching a shared understanding of a situation with those involved in order to construct ‘theories' about the meanings and problems that arise in that situation and - in agreement with that - create solutions that are appropriate, comprehensible, and applicable. The researcher's responsibility is to develop this process in such a way - along with those involved - that the uniqueness of the situation is done justice. This entails selecting methods that allow people to learn how to discover and alter their own reality. Throughout the process, the researcher gains knowledge about the organization, a learning process shared also by all people involved. The notion of validity, in this context, is transformed in an entirely different meaning. This concept is also known as **constructivism**.

Both interpretations can be further developed in several ways. What is crucial here, however, is that the methodology and theory of knowing are directly linked. A connection is formed, through the nature of the question, between the problem being examined and the way in which the researcher approaches the problem respectively. If any of the premises and assumptions about the phenomenon (subject or object) to be studied are not taken into account, it is impossible to design a specific form of research in a prudent manner, let alone a specific type of methodology. As a result, selecting a specific methodology is not something that happens randomly.

- ***Pragmatism***

Rather than antecedent conditions (as in positivism), **pragmatism** as a paradigm emerges from situations, actions, and consequences. Instead of concentrating on methods, researchers stress the research problem and employ all available approaches to comprehend it. Pragmatism is not tied to a single system of philosophy and reality. This applies to mixed methods research as inquirers draw largely from both quantitative and qualitative assumptions when they engage in their research. Individual researchers have the ability to make their own choices. Researchers are thus free to select the research methods, techniques, and procedures that best suit their needs and objectives. Pragmatists do not look at the world as an absolute unity. Similarly, mixed methods researchers use a variety of approaches to gather and analyze data rather than committing to a single method (e.g. quantitative or qualitative). Truth is what works at the time; it is not built on a duality between reality outside of the mind or inside the mind. As a result, investigators in mixed methods research combine both quantitative and qualitative data in order to deliver the best understanding of a research problem. Pragmatist researchers consider the *what* and *how* to research, depending on the desired consequences -where they want to go with it. Mixed methods researchers must first define a purpose for their mixing, a rationale for why quantitative and qualitative data should be mixed in the first place. Pragmatists agree that research always takes place in a variety of contexts, including social, historical, political, and other. Mixed methods studies, in this way, may include a postmodern shift; a theoretical lens that reflects social justice and political goals. Pragmatists believe in both an external world independent of the mind and one lodged within it. However, they believe we must stop asking questions regarding reality and laws of nature (Cherryholmes. 1992). Therefore, for the mixed methods researcher, pragmatism opens the door to various methods, multiple worldviews, and different assumptions, as well as different data collection and analysis methods.

- ***Conceptual Analytic***

Conceptual analysis in pracice concerns distinguishing terms, analyzing the understandings they relate to, and expressing the results. Concepts encompass some of the most fundamental issues or phenomena associated with a discipline. (Cocchiarella, 1996, p. 8). Concepts can, therefore, be considered to relate to Plato's 'Forms' or Aristotle's 'Universals' (an abstract idea or mental image). A concept is a theoretical term referring to a property or construct (typically a complex entity or phenomenon) that indicates the role it plays in a theory, or in connection to other concepts; it is the idea embodied by a term or word. Outside of thought, a concept cannot have meaning or representation; it must be communicated in language, and concepts are built to this extent. Concepts develop a framework for comprehending, making sense or meaning of the world, and they are expressed in an ontology.

Consequently, the issue at hand is to discern the concepts that such definitions might express, rather than a set of definitions that are suitable for the field. Burgin is concerned that a ‘valid and efficient theory of information’ does not rest on ‘a correct definition of information’, but rather a clearer comprehension of the ‘properties of information and information processes’ (Burgin, 2003, online). Thus, the aim is to find the narratives that are operationalized in this discourse, which cannot be found by the atomizing analysis of selected words and phrases, but rather by looking at whole-text 'explanations' or 'procedures' that professionals use in their daily practice.

Nevertheless, the canonical or seminal concepts of a knowledge domain need to be evident regarding their attributes and relations. Concepts and the theories in which they are embedded have a reciprocal, mutually reinforcing effect: a theory's ontological commitments can be expressed in terms that represent the concepts with which the theory deals. At the same time, a theory cannot be developed unless the concepts (and the attributes of the concepts) with which it deals have been established quite clearly. Concepts, according to Thellefsen (2004), belong to ideas and are conditional and provisional rather than fixed: they are not neutral since they correspond to and are inspired by paradigms and ideologies. (Thellefsen, 2004, pp. 69–72).

3.1.3 Research Strategy

The selection of the research design leads to the determination of the research strategy that will be followed. Research strategies are categorized in qualitative encompassing five main categories and quantitative including two main categories. Their explanation is presented in the next sections.

3.1.3.1 Qualitative Research Strategies

- **Ethnography** is a strategy of research in which the researcher collects data from an intact cultural group in a natural setting over a long period of time, mainly via observations and interviews (Creswell.

2007b). The research approach is adaptable, and it usually evolves according to to the lived reality encountered in the field setting (LeCompte & Schensul. 1999).

- **Grounded theory** is a research strategy in which the researcher develops a general, abstract theory of a process, activity, or interaction grounded in the views of participants. Multiple phases of data gathering, as well as the refining and correlation of categories of information, are used in this process (Charmaz, 2006: Strauss and Corbin. 1998). The continuous comparison of data with emerging categories and the theoretical sampling of different groups to maximize the similarities and dissimilarities of information are two primary characteristics of this strategy.

- **Case studies** are an inquiry strategy in which the researcher investigates a program, event, activity, process, or one or more individuals in depth. Time and activity define the boundaries of a case. Detailed data and information are collected by researchers over a sustained period of time, utilizing a variety of data collection methods (Stake, 1995).

- **Phenomenological research** is a strategy in which the researcher identifies the essence of participants' experiences, as described by them, about a phenomenon. Phenomenology is both a philosophy and a method for understanding life experiences, and the procedure entails studying a limited number of subjects through extensive and prolonged engagement in order to create patterns and correlations of meaning (Moustakas, 1994). The researcher should bracket or set aside his or her own experiences, during the research process, in order to comprehend the experiences participants in the study (Nieswiadomy. 1993).

- **Narrative research** is an inquiry strategy in which a researcher observes the lives of individuals and requests one or more of them to share their stories. The researcher typically retells or restories this information into a narrative chronology. In the end, the participant's and researcher's views of life are combined in a cooperative narrative. (Ciandinin & Connelly. 2000).

3.1.3.2 Quantitative Research Strategies

- **Survey research** provides a quantitative or numeric representation of trends, attitudes, or opinions in a population by examining a sample of this population. Cross-sectional and longitudinal studies that collect data using questionnaires or structured interviews are included with the objective of extending findings from a sample to the entire population. (Babbie, 1990).

- **Experimental research** is usually used in lab conditions and aims to determine if a particular intervention (e.g., a treatment) in a human or object characteristics affects an outcome. This impact is evaluated by experimentally intervening to a specific group and withholding it from another in order to determine how both groups scored on an outcome. True experiments, in which individuals are randomly assigned to intervention conditions, and quasi-experiments, which utilize nonrandomized designs, are both examples of experimental research (Keppel. 1991).

3.1.4 Research Purposes

According to **Sue and Ritter (2012)** the research studies can be classified into three main categories based on their purpose. These categories are:

- ***Exploratory Research***

The aim of exploratory research to define issues, clarify concepts, and generate hypotheses. A literature search, a focus group discussion, or case studies can all be used to start the exploration process. When performing exploratory research, no attempt is made to study a random sample of a population; instead, researchers conducting exploratory research look for people who are knowledgeable about a topic or process. Rather than testing hypotheses, exploratory research aims to create them. Qualitative data is used in exploratory studies, collected by brainstorming meetings, expert interviews, or by submitting a brief survey to a social networking website are all examples.

- ***Explanatory Research***

The main purpose of explanatory research is to explain why phenomena occur and to predict future occurrences. Explanatory studies are distinguished by research hypotheses that define the nature and direction of the interactions between or among the variables being examined. Because the objective of explanatory research is usually to generalize the results to the community from which the sample is selected, probability process is normally required. The collected data are quantitative and almost always require the utilization of statistical tests for the establishment of the validity of the relationships. For example, explanatory survey research, may investigate the factors that impact customer satisfaction and determine the relative weight of each one, or it might try to model the variables that lead to shopping cart abandonment. An exploratory survey uploaded on a social networking platform might reveal that a company's consumers are dissatisfied. An e-mail survey sent to a random sample of customers who made a purchase in the previous year might be used to report the kind and degree of dissatisfaction. So, in this case the research or survey attempts to explain how various factors contribute to consumer dissatisfaction.

- ***Descriptive Research***

Descriptive studies have more guidelines than the other categories. There are additional guidelines in descriptive research. They are used to describe people, things, and situations. Descriptive studies often include one or more guiding research questions, but they are not typically driven by structured research hypotheses. A probability sampling technique, such as simple random sampling, is frequently required, because this type of research frequently attempts to describe characteristics of populations based on data collected from samples. Data from descriptive research may be qualitative or quantitative. Quantitative data presentations are usually limited to frequency distributions and summary statistics, such as averages. Descriptive projects examples are customer satisfaction surveys, presidential approval polls, and class assessment surveys.

3.1.5 Research Quality (Reliability and Validity of the Study)

After the completion of each study the checking of the research quality is necessary. The two main characteristics that are taken under consideration for the checking of quality are ***reliability*** and ***validity***. ***Reliability*** refers to the consistency with which a questionnaire, summated scale, or item can be administered to the same people repeatedly and provide the same results. As a result, it assesses the study's capacity to be replicated. Although reliability is necessary for establishing validity, it is not sufficient (Schwab, 1980). If a measure yields inconsistent results, even very highly valid results are meaningless. ***Validity*** is a way of measuring two things. First and foremost, does the item or scale actually measure what it is supposed to? Second, does it take into account anything else? If the answer to either of these questions is "no", then, the object or scale shouldn't be utilized. When an invalid object or scale Is used, it's like attempting to measure inches with a meter stick; accurate quantitative data can be gathered, but it's useless. ***Respondent validation***, also known as 'member checks,' is a technique for ensuring study validity used in qualitative and mixed methods texts (Creswell, 2003; Lincoln and Guba, 1985, Teddlie and Tashakkori, 2009) It involves research participants responding to forms of initial data, such as transcripts of interviews or observations of activities, in order to check them for accuracy, or to first drafts of interpretive reports, again, to their accuracy, as well as, to the interpretive assertions that are being made (Bloor, 1978; Lincoln & Guba, 1985). The involvement of research participants in both processes is an option for researchers. They can double-check the accuracy of the initial data collected, as well as whether or not participants have more to contribute to the transcript of their interview(s) when they have more time to reflect on the topic that is analyzed. They might also be questioned on whether the developing account can be considered a fair and reasonable representation of the situation as they comprehend it.

3.2 Research Framework

The structure of this empirical reference model development (research design, data collection, data analysis, and research quality) follows the guidelines described by Flynn et al. (1990) about empirical research in operations management. In **Figure 3.1** the completed research framework that was utilized in this dissertation is depicted, following the already presented categorization from the previous sections. According to the presented research framework, in this qualitative study (research design), the constructivist view (research paradigm) is followed as, by the observation and the active engagement with organizations' operation, the researcher was led to the construction of a framework to confront the addressed problems (Creswell, 2009). This dissertation presents an empirical study, since it proposes a framework, based on data collected by actual experience, observations, and study of real cases guidelines rather than theory and belief, to guide the implementation of LSS in the designed supply chain business processes. This research can be also described as exploratory (research purpose) because it takes a specific research topic into consideration, such as LSS implementation in retail supply chain processes, and extends its scope in more detail to fill a gap in the literature. The model developed in this dissertation is configured in the form of a business process reference model.

The qualitative research strategy of this empirical research is based on case studies, as the data needed for the construction of the reference model are gathered by two companies and the implementation is conducted in one of the two participating companies. The data collection is supported by interviews and conversations on the same subject with both companies. After the collection of the appropriate information through the interviews and the meetings, in which employees of the companies described their everyday job steps and the trends of the retail supply chain in the form of a conversation, the analysis of this information followed; their combination, along with best practices proposed in literature or implemented by the largest companies of the sector, led to the construction of the business processes and the LSS proposed initiatives that the reference model consists of. Finally, the research quality is taken under consideration for the assurance of the reliability and the validity of the research conducted and the developed model. Thus, checking whether the same data collection activities can bring the same results if they are repeated (*reliability*) and, at the same time, whether the data collection and analysis processes are robust and can achieve their goal of developing the reference model (*validity*) should be examined.

Consequently, the reliability of the research is assured, as the same process of data collection is repeated successfully in both companies. Employees with same roles in the supply chain of each company are asked to give the necessary information about the same processes. The validation of the research is conducted through respondent validation (member checks) in various stages of the reference model development for better evaluation, as new evidence come to light during the process (Torrance, 2012). Specifically, after the first round of data collection, each company is asked to review and confirm the appropriateness of the recorded information or suggest corrections and data additions in specific areas, which lead to a second round of data collection. Each company also conducts, separately from the other, the review of the modeled processes and, after each company's validation, the combined model is presented to both retailers in order to propose corrections and end up in an agreement regarding both the final supply chain processes and the proposed LSS initiatives. Thus, it is ensured that the modeled processes are coming in accordance with their guidelines and operations as described, and the proposed LSS initiatives are corresponding with their experience and knowledge of the trends and the contemporary methods implemented in the retail supply chain. The final validation of the model is conducted through a case study in which the implementation of a part of it in one of the participating companies leads to inferences about its effectiveness.

Research Framework

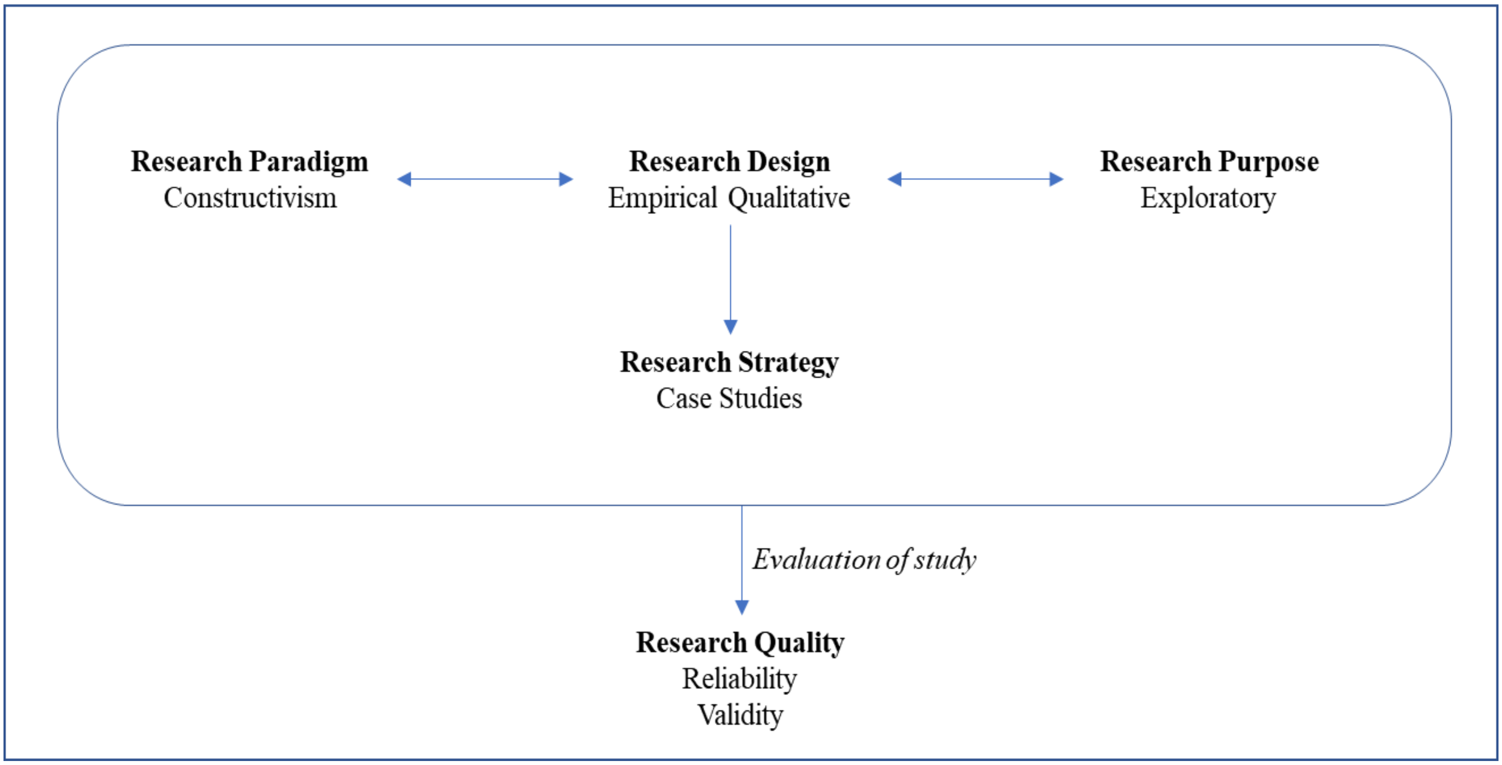


Figure 3.1. Research framework of the dissertation

3.3 Methodology of Model Development

The phases of the methodology that were selected for developing the proposed model are presented in **Figure 3.2**. The starting point, after the identification of the gap, was the search and the analysis of the LSS literature in order to recognize potential areas of the supply chain where the LSS methodology can contribute to the improvement of the processes. After this review, the selection of modeling views and related information needed for the construction of the model to combine business processes with LSS initiatives was clearer. For the collection of the necessary data and information, the method of qualitative research was adopted. For the modeling of the supply chain processes included in the LSS RSCPR, the conduction of interviews and a series of meetings with the executives and employees of the two largest (multinational/ national) retail companies in Greece were necessary in order to configure a complete image about retail processes and combine the collected information from different perspectives and different organizational levels. The size of the companies and their available resources for investments in improvement initiatives were two crucial factors for the successful development of the reference model, along with the maturity of their supply chains. The multinational company has 510 stores and employs 14,000 people, while the national company has 429 stores and employs 28,000 people. The duration of the data collection from the companies was almost one year -from the 6th of October of 2019 until the 5th of November of 2020- and led to the modeling or remodeling of their processes to clearly determine which activities can be improved by LSS initiatives. In both cases, the interviews were carried out with employees of similar positions that were working in the Logistics, Merchandising, and Sales Departments. More specifically, from the Logistics Department, the Distribution Directors, Warehouse Managers, Planning Managers, Transportation Managers and employees from lower management levels, like activities supervisors and loaders/ pickers participated. From the Department of Merchandising, the Purchasing Directors, Category Managers and Buyers participated. Sales Managers and employees from the Department of Sales contributed as well, along with Store Managers. The total number of days in which the interviews were conducted for the configuration of the reference model was 117. A meeting with the management team was taking place at the end of the weeks that interviews were conducted, in order to sum up the findings and the collected data. 33 meetings were organized in total for the overview of the collected data and the discussion about the guidelines that should be followed for the modeling of processes or the correction of the already existing processes, as well as the determination of the activities which can be improved by LSS.

A first investigation of the level of each company's supply chain processes took place. It was decided to start the process modeling from one of the companies and then, to compare its processes with those of the other company in order to make necessary alterations or additions and include all the crucial information related to the supply chain operation. The development of the model was based on the ARIS (Architecture for Integrated Information Systems) Architecture, utilizing a selected range of models and modeling objects. The views that were used for the construction of the LSS RSCPR were decided to be the organization and the process, as the methods included in them were able to completely construct the proposed reference model. A more detailed description of ARIS is presented in *Section 4.1.3*. Both the qualitative approach that was followed in this dissertation and the case studies approach are appropriate techniques to study in-depth developing scientific areas, such as the integration of LSS in retail supply chain and to better understand them (Ellram, 1996; Yin, 1994; Mollenkopf et al., 2007; Manuj and Mentzer, 2008; Thomas and Esper, 2010, and Godsell et al., 2010). Qualitative research offers researchers proximity to the studied subject and gives a better perception of the general context. Davis and Mentzer (2006) argue that qualitative research is the most accepted and useful approach to address the topic of supply chain and suggest the use of interviews when qualitatively analyzing this topic.

Thus, the information and data gathered led to the modeling of the supply chain processes which was followed by the verification of the models in cooperation with the employees of the organizations that were involved in the designed processes. An important aspect of the processes design is that, apart from the description of the companies about their own operations, generalized information about the retail supply chain processes was gathered by studying the best practices that are presented in the literature (textbooks and papers). The literature best practices and the information and data of the companies were correlated in order to decide which activities should remain, be added, or deleted in each process. In addition, the Distribution Director of one of the companies, that is a subsidiary of a major multinational retailer, gave the researcher insights about the best practices that the parent company systematically records and analyses, in order to implement them in its operation model and processes. Consequently, the final processes were configured based both on the activities described by the participating companies and the best practices described in the literature, the majority of which are implemented in the parent company of one of the participated. The final modeled processes were evaluated by the participating companies during the verification phase in order to ensure that the information and data were correctly used and depicted. After the assurance of the processes' correctness, the integration of LSS initiatives to key activities was identified according to the directions of the companies which proposed areas encompassing crucial activities and following the international best practices. The connection of the key activities to the LSS initiatives was the final step for the development of LSS RSCPR. After the completion of the reference model, a final version was shared with the companies that took part in the data collection phase. For the comprehension of the reference model by the companies, a detailed description of the processes and the LSS initiatives was composed along with a dictionary of the ARIS methods and objects that were used. The "sign-off" of the reference model by the two companies was an indication of the appropriateness of the model that could be further tested and validated through case studies in organizations of the retail sector.

It is important to mention that the model investigates the supply chain from the scope of the retailer. For this reason, the processes that are included and the improvements that are proposed mainly concern the operations of the retailer. However, the retailers, especially the large retailers, have dominant role in the supply chain, influencing the whole network and implementing their own rules. Thus, in several processes and improvement actions, external stakeholders of the supply chain, such as the suppliers, are presented to participate, apart from the retailer, in order to point out how the processes of the retailer are closely related to those of other supply chain participants. As a result, the LSS RSCPR shows a clear picture the flow of the whole supply chain, through the modeling of the retailer's processes and the proposed improvement actions that take under consideration the cooperation of supplier and retailers.

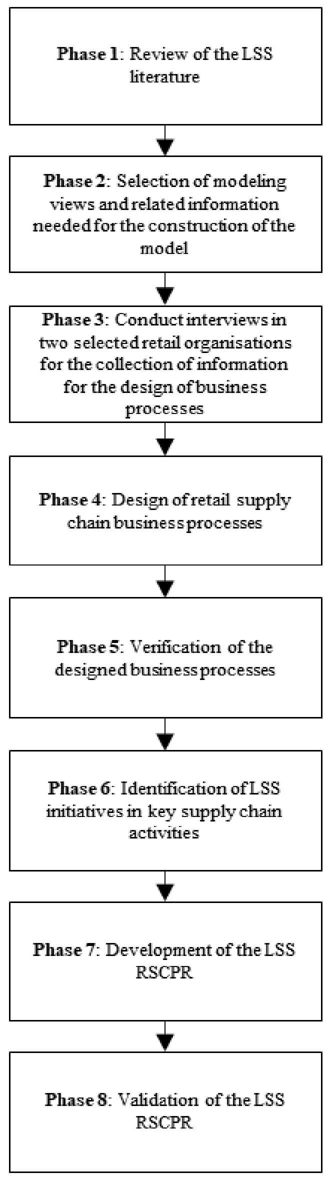


Figure 3.2. Methodology followed for the development of the LSS RSCPR

4. Lean Six Sigma Retail Supply Chain Process Reference Model (LSS RSCPR)

4.1 Business Processes, Reference Models and Architectures

The framework that is proposed in this dissertation is a reference model of business processes which was based on a specific business architecture. In addition, the improvements of supply chain processes that are proposed in this reference model, through the implementation of LSS, are included in the wider notion of Business Process Improvement. For this reason, this brief introductory chapter has been written before the presentation of the model in order to explain the basic notions that constituted the pillars of its development.

4.1.1 Business Process Improvement

BPI has been coined in 1991 by James Harrington (Harrington, 1991). Any process-based change has been referred to as BPI. Although it is a well-known term, numerous terminologies are loosely linked with it. To understand this concept, it is helpful to review some basic term. The term "process" is a core concept that has gotten a lot of attention and a lot of diverse interpretations from various perspectives (Childe et al., 1994; Harrison, 1995). A popular definition is:

"The transformation of inputs into outputs; the inputs can be resources or requirements, whilst the outputs can be products or results. The outputs may or may not add value and could be an input to another process" (Harrington, 1991).

The phrase "business process" is used when this notion is applied to a commercial organization. In the literature on the design and management of business processes, a number of particular definitions have become generally adopted. Tinnila (1995) defines a business process as follows::

"A group of logically related tasks that use the resources of the organisation to provide defined results in support of the organisation's objectives".

BPI suffers from a lack of widely accepted definitions. BPI is frequently regarded as a methodology for achieving step function improvements in administrative and support processes using techniques such as process benchmarking, process redesign, and process reengineering (Harrington et al., 1997).

A completed framework for the deployment of BPI was proposed by Adesola and Baines (2000) combining the basic principles of BPI as described by Kettinger et al. (1997), Harrington (1991), Smart et al. (1998) and Klein (1994). The cycle of this framework includes 7 steps, as depicted in **Figure 4.1** and the explanation of the steps is presented in **Table 4.1**.

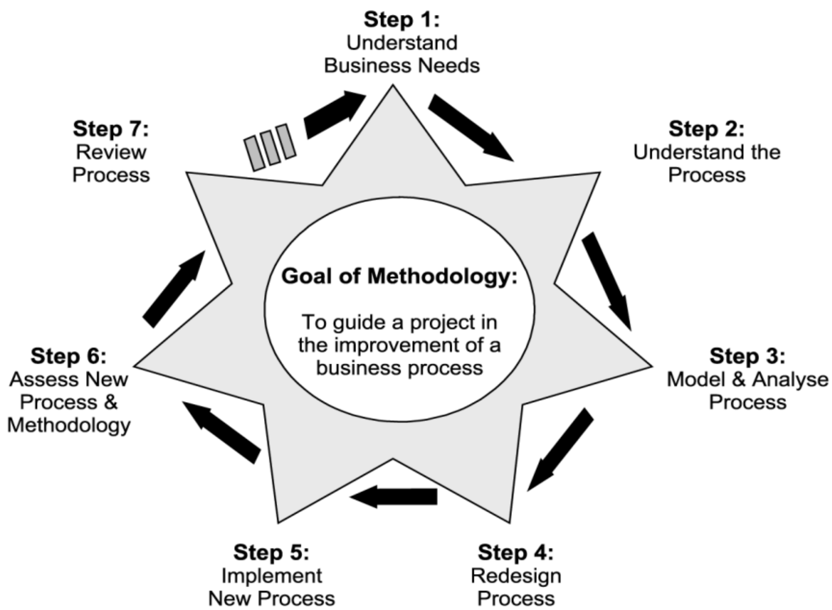


Figure 4.1. BPI framework (Source: Adesola and Baines (2000)**)**

Table 4.1 Analysis of the steps of BPI framework (adapted from Adesola and Baines (2000)

Steps	Step Description
1. Understand business needs	Develop vision and strategic goals
	Analyze competitors
	Develop organisational model
	Evaluate current practices,
	Prioritise objectives
	Scope change
	Set measurable targets and goals
	Establish process objectives and assess readiness
	Obtain approval and initial project resource
	Benchmark the process
2. Understand the process	Determine the architecture of the business process
	Scope and define the process
	Capture and depict the as-is model process information

Steps	Step Description
	Create a process model
3. Model and analyse process	Verify and validate the model Measure the existing process performance Analyse the business process
4. Redesign process	Benchmark the process Determine performance criteria for the re-designing of the process Identify the focus of the re-design activity Model and validate new "to-be" process Determine IT requirements Measure the performance of the re-designed process
5. Implement new process	Make a plan for implementation. Obtain approval for implementation. Examine change management strategy Communicate the change Technological development Make new process to be operational Train personnel Roll-out changes
6. Assess new process and methodology	Conduct process deployment and analysis of performance data Revaluate organisational approach
7. Review new process	Create a strategic vision of the business Set process and performance targets Develop a plan to reach targets Implement plan

4.1.2 Business Process Reference Model

Reference models are called universal models, generic models, or model patterns, as well. The term "reference model" for business processes describes a specific type of reference model. A business process reference model represents and includes dynamic aspects of an enterprise, like activity sequences, organizational activities required to meet customer needs, control-flows between activities and particular dependency constraints (Becker et al., 2003; Fettke et al., 2006). Based on the study of Fettke et al., 2006, who evaluated and assessed 30 process reference models, **Figure 4.2** illustrates and structures the criteria for characterizing process reference models. In addition to generic features that are applicable to a wide range of reference models, the description and categorization of process reference models specific attention to process-related criteria.

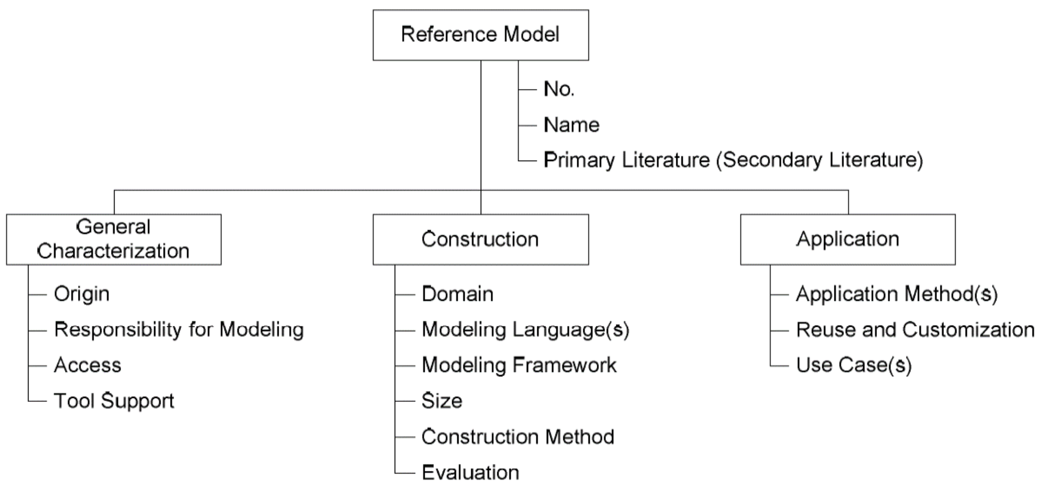


Figure 4.2. Criteria for characterizing reference models (Source: Fettke et al., 2006)

- ***General Characterization***: The following four criteria generally characterize a reference model.

  1. *Origin*: The origin provides information on the classification of the person(s) who created the reference model. Both science and practice can be differentiated in this way.
  2. *Responsibility for Modeling*: The people or organizations who developed the reference model are described in this criterion.
  3. *Access*: Third-party access to the reference model is defined via the access parameter. The reference model is classed as "open" if it is entirely accessible using traditional librarianship methods. If the responsible person(s) or institution does not allow third parties to use and recognize the reference model, it is considered "closed." The access is characterized as "limited" if it is neither open nor closed. This is the case, for example, if the reference model may be purchased separately. If access to the reference model is restricted, the information for all the preceding and subsequent criteria is based on statements from the primary and secondary literature.
  4. *Tool Support*: This criterion specifies if a software tool can automatically utilize the reference model or whether it is only available in paper or digital form.

- ***Construction***: The following six criteria address the construction of process reference models:

    1. *Domain*: From the viewpoint of the person(s) or institution responsible for producing the reference model, the domain specifies the field of application. Domain differentiation and domain description are two types of criteria. Defining domain differentiation helps to distinguish between different domain classification principles. Several techniques to differentiation have been presented so far. Different principles of differentiation can be identified as a result: Institutional differentiation is based on the desired business system's institutional features (e.g. “Industrial Enterprise” or “Bank”); functional differentiation is accomplished through business functions as differentiation characteristic (e.g. classical business functions: “Distribution Logistic”, “Production Planning and Control”; newer functions: “Facility Management”, “Knowledge Management”); object-driven differentiation lies where business objects serves as differentiation characteristic (e.g. “Life Insurance” or “Branch Business”); enterprise type driven differentiation relies on special enterprise characteristics (e.g. a book publisher can be considered as a special type of a publisher). There are also other universal reference models that cannot be categorized using the aforementioned criteria. Aside from domain differentiation, the domain description uses brief descriptions to specify the intended field of application for the reference model.

    2. *Modeling Language(s)*: The modeling language used to represent the reference model is specified by the language criteria. Modeling languages or diagram types used to describe process models of the reference model are specifically defined to address the special consideration and description of process reference models.

    3. *Modeling Framework*: This criterion determines if the reference model includes a modeling framework. At a higher level of abstraction, a framework can organise relevant elements, such as diagrams of a reference model and their relationships. This minimizes complexity and offers an overview of the reference model's elements and relationships.

    4. *Size*: There are currently no acceptable size measures for models in various modeling languages (Van Belle, 2003). Several metrics may be utilized to get a general idea of the size of the described reference models. General characteristics include the number of represented diagrams and views. The number of process steps within depicted process diagrams is expressed as a process-related metric. The sizes of smaller models (<30) will be counted, while the sizes of larger models will be estimated and rounded off to the next decade. The information is based on claims of provided references if the model's access is closed.

    5. *Construction Method*: The modeling approach utilized by the responsible person(s) or institution to construct the reference model is stated in this criterion.

    6. *Evaluation*: This criterion outlines the methods utilized by the person(s) or institution responsible for establishing the reference model, as well as third parties, to evaluate the reference model. Only evaluation methods that are explicitly intended for model evaluation by the evaluator are considered. It is also indicated whether the outcome of the executed evaluation is inter-subjectively verifiable, in addition to the method.

- ***Application***: The following three criteria address the application of process reference models:

    1. *Application Method(s)*: This criterion defines the for applying the reference model.

2. *Reuse and Customization*: In the context of the model's application, this criterion provides concepts for reusing and modifying model elements.

3. *Use Case(s)*: The number of times the reference model was used to build an application model is provided in the use case(s). This criterion, like the evaluation method, is completed with information on whether the number and extent of use cases are inter-subjectively verifiable.

4.1.3 Business Process Architecture and ARIS Architecture

A business process architecture consists of a set of business processes and their interdependencies. Business process architecture design methods have mostly utilized the following types of relations (Dijkman et al., 2011):

- *composition*, which shows that a single business process consists of several additional business processes, called sub-processes.;
- *specialization*, which represents that a business process specializes another;
- *trigger*, which indicates that a business process "pushes" another business process to instantiate and start; and
- *information flow,* which describes the flow of information or other objects from one business process to another.

The business process architecture that was selected for this model development is ARIS.

ARIS has been developed by Professor A.W. Scheer and it is a typical example of defining standardized general concepts – what's so called architecture (Rippl, 2005). Models for designing, analyzing, and evaluating business processes are provided by ARIS. ARIS is a process-oriented architecture which aims at the integration of the information system technologies in the improvement of the processes of a company. (Scheer, 1992). The tools and methods that ARIS offers can support the modeling and improvement of business processes, utilizing different views (organization, data, function. process, output) in order to reduce the complexity of the models (Scheer, 1994). The several views of the architecture provided by ARIS are an efficient benefit, as they decrease the ambiguity that other models create when attempting to develop a complete architecture for large organizations. In ARIS, the relationships between the various views are strictly defined. **Figure 4.3** introduces ARIS House of Business Engineering. The organizational view depicts the organization's uses and units (who), the data view represents information objects (what information), the process (control) view depicts the functions to be performed (is doing what), the function view presents the activities, and finally the product depicts the output provided (a service or product). Another effective way for ARIS to decrease complexity is to introduce multiple descriptive levels, which guide analysts from the business problem to the technical implementation (Rippl, 2005). As also stated by Rippl (2005), "the essence of ARIS architecture is the combination of descriptive views and descriptive levels. Every descriptive view is described at the three levels of requirements definition, design specification, and implementation". According to Tang and Hwang (2006) Christian et al. (2006) the separation of these three levels clarifies the consistency between enterprise application programs and information technology. This gives ARIS an edge over other modeling tools like UML and Integrated Definition Function Modelling in that it conducts a more comprehensive breakdown from four perspectives, resulting in a less complicated architecture that can be improved over time.

For the modeling of the reference model presented in this study ARIS Architecture was selected, as with utilization of the methods of different views all the perspectives that are proposed by Curtis et al. (1992)

and later in a slightly different way, but with the same pattern, by Luo and Tung (1999) are fulfilled. Specifically, the proposed perspectives in modeling business processes are:

- *"functional" perspective*, where the elements of the process that must be performed are identified;
- *"behavioral" perspective*, a model that shows when process elements are assigned and how associated actions are performed;
- *"organizational" perspective*, which indicates who performs process elements and where, and finally;
- *"informational" perspective*, which presents what informational entities are produced by a process such as data, documents, etc.

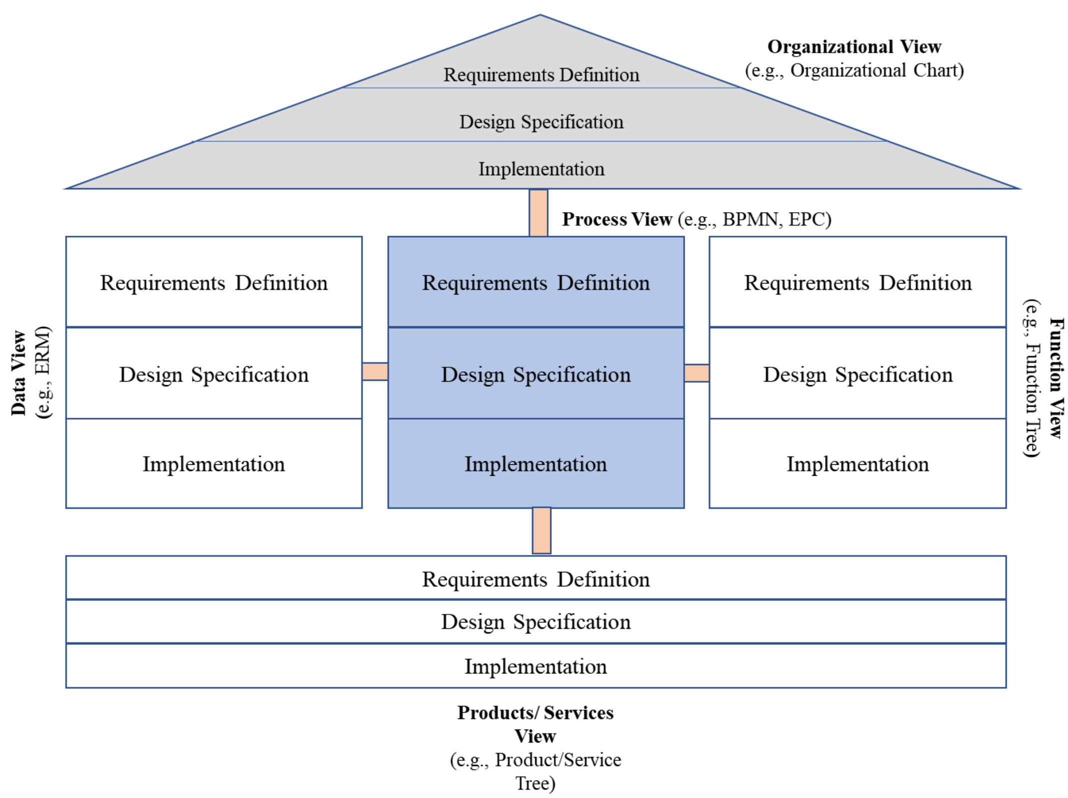


Figure 4.3. ARIS house

4.2 Description of Model Structure

In order to be able to construct the model, a necessary elaboration of the collected data had to be made for the determination of the information that should be represented and how this information should be connected. In **Figure 4.4** an Entity Relationships Diagram (ERD) is represented including all the entities that were taken under consideration for the development of the reference model along with the relationships among them. The central component of the model is the Business Process in which specific Stakeholders (Departments, Managers, Supervisors and Employees) participate to execute the activities that are included in each process. There is a hierarchical decomposition of processes to sub-processes and activities. The lowest level of detail is achieved with interconnected activities, providing a more comprehensible representation of the processes. Specifically, the activities encompass the following information:

- Information systems supporting activities
- Necessary equipment for the execution of activities
- Shared Documents
- IoT technologies to enhance automation
- Business policies that can facilitate the organization and the operation of a retail company
- Risks interlaced with the activities that can be mitigated by connected controls
- KPIs measuring the efficiency of activities

Apart from the connection of activities with a more detailed analysis about them, the model proposes selected activities of supply chain processes which can be improved through LSS initiatives. These LSS initiatives are grouped in LSS improvement areas, depending on the type of supply chain activities and following the flow and the operations steps of retail supply chain. 15 LSS improvement areas were recognized in total, including: Forecasting, Merchandise Purchasing, Merchandise Receipt Preparation, Merchandise Unpacking, Merchandise Storage, Cross-Docking Addition, Cross-Docking Execution, Placing of Stores' Orders, Bach-Hauling, Picking/Packing, Distribution Plan Configuration, Loading to Trucks, Distribution Execution, Collaboration with Vendor/Vendor Managed Inventory, and Reverse Logistics. This is the second part of the LSS RSCPR that assigns LSS projects to activities which are candidates for potential improvement. LSS initiatives are proposed as improvement actions. The driving force of improvement actions is the analysis proposed by the model which follows the DMAIC phases and has the aim to highlight typical vulnerable points. Each DMAIC phase consists of specific activities that should be accomplished in order to be completed and bring results. The model includes a pool of LSS tools for each DMAIC phase, with free selection according to the needs of each project, guiding the project team involved in the improvement initiative.

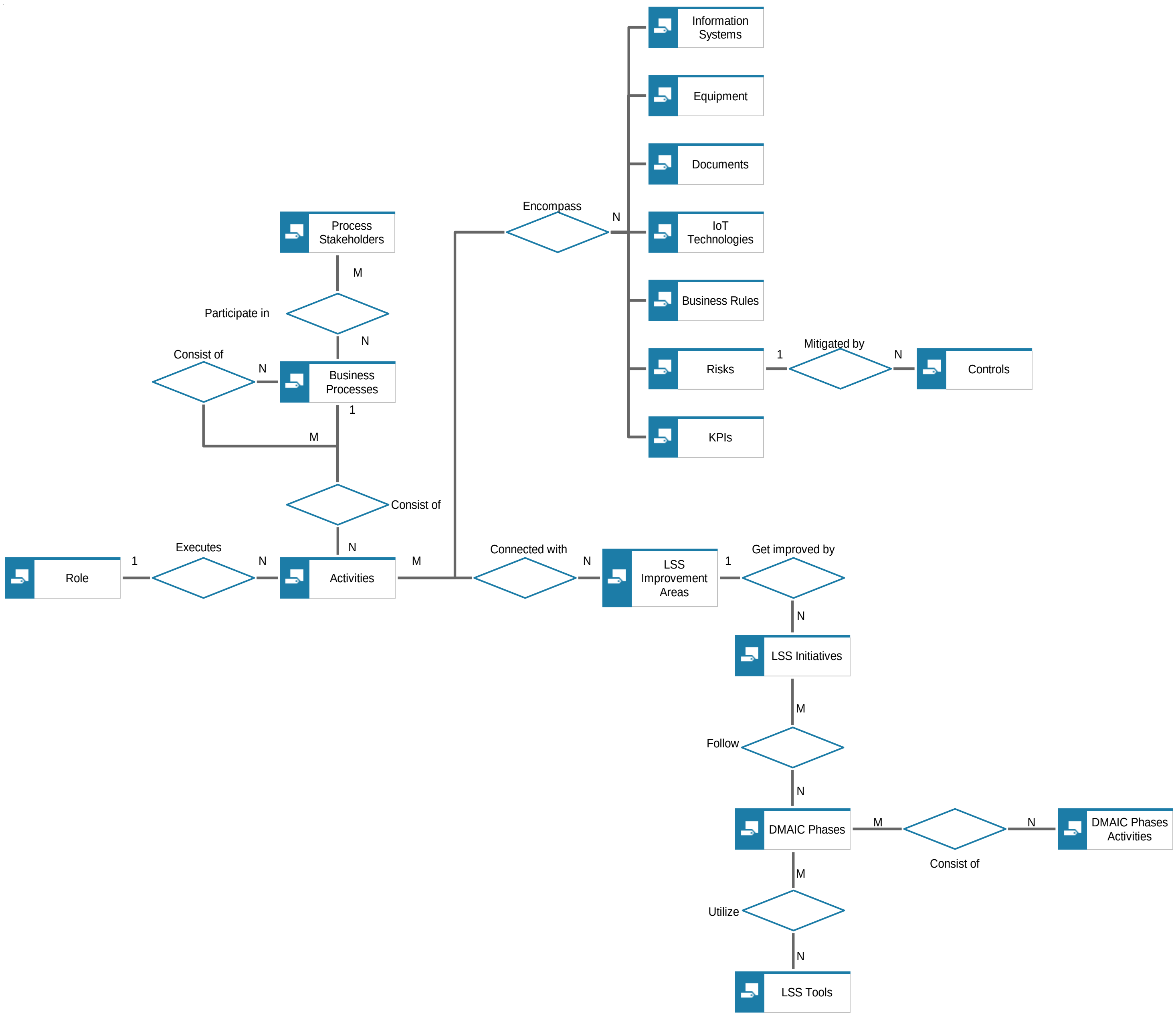


Figure 4.4. ERD presenting the entities included in LSS RSCPR

The architecture that was used for the depiction of the model was the ARIS architecture. The information that was decided to be included in the LSS RSCPR determined the structure of the views, the methods and the objects that were utilized in order to represent a clear and comprehensive picture of the processes and incorporated LSS initiatives. The modeling methods and the objects that were utilized, as well as the connections among them, are presented in **Figure 3,** allocated in two different views. The views that were utilized for the development of the LSS RSCPR were selected for the complete presentation of all the aspects of the steps and activities that should be fulfilled for the execution of processes and, as a result, the implementation of LSS. According to Dumas et al., (2018) the components that must be included in a business process model in order to depict all the necessary information and present the flow of information in processes are *actors of the process* such as participants (internal or external) that execute activities and information systems that act on behalf of humans, *physical objects* such as paper documents, and *informational objects*, such as electronic documents. The contribution of these components is significant in the comprehension of processes and the views presented in **Figure 4.5** were chosen by taking into account these components and their appropriateness in the construction of a sector-specific business process reference model.

The organizational view includes the Organizational Chart which is constituted by Organizational Unit objects representing proposed company's departments and Role objects representing proposed company's employees participating in the execution of processes and activities.

The process view encompasses five types of methods (types of diagrams):

- **Value-added chain diagrams (VACD):** VACDs present the high-level classification of processes using the Value-Added Chain object for each process. Each value-added chain object corresponds to a related BPMN collaboration diagram.
- **Enterprise BPMN collaboration diagrams:** BPMN diagrams are used for the modeling of business processes and the interaction among participants. Pools, Organizational Unit Lanes and Role Lanes objects represent the participants of the processes. Within the pools and lanes, there are Tasks depicting the activities that every participant executes in the process and Events to show occurrence of a business management-relevant state that controls or influences the progression of business processes (e.g. sharing of information, messages, triggers of processes). Gateways objects are also included for the merging (AND), alternating (OR) or diversion (XOR) of the flow. Data objects symbolize the documents shared in specific process steps. Finally, Application System Type lanes are used to show important steps of the process that are executed by information systems.
- **Function Allocation Diagrams (FAD):** FADs act as supplements of BPMN diagrams in order to provide more details for specific important activities. Task objects are the same as those in BPMN diagrams. Role, Organizational Unit and External Person objects show the contribution of participants in activities that have not been included in BPMNs. Business Rule objects show the business rules related to. Risk objects present the risks connected to activities and Control objects show how to mitigate risks. Application System Type objects depict the Information Systems supporting the activities. For the presentation of information needed or produced by the Information Systems, the objects of Electronic Folder, Electronic Document, and Information Element were selected. Warehouse Equipment Type objects, IoT objects, Bar Code objects and Mobile Phone objects are used for the depiction of specific equipment and characteristics needed for the completion of activities. In addition, KPI Instance objects are used for the proposed KPIs for the retail supply chain operations.
- **Event-driven Process Chain Diagrams (EPC):** EPC diagrams are the second core pillar of the LSS RSCPR and are used for the presentation of LSS improvement areas. These are connected to specific activities of BPMN diagrams (activities that are recognized as candidates for LSS initiatives) and follow the DMAIC method to propose improvements in the processes. Event objects in this occasion help in the representation of flow of the DMAIC method by adding milestones in the beginning of its implementation. Function objects represent the activities that should be followed by companies in order to implement DMAIC. Target Function objects represent the LSS initiatives (improve actions of the improve phase) which need to be adopted for the improvement of processes. Finally, Rule objects (AND, OR) merge and diverge the flow wherever this is necessary.
- **Knowledge Structure Diagrams (KSD):** Knowledge Structure Diagrams and their Knowledge Category objects were utilized for the categorization of the suggested LSS tools in each DMAIC phase, symbolizing the knowledge needed for the application of tools. In the reference model there is a connection between EPC Diagrams and Knowledge Structure

Diagrams as every DMAIC phase in an EPC can utilise the tools described in the corresponding KSD.

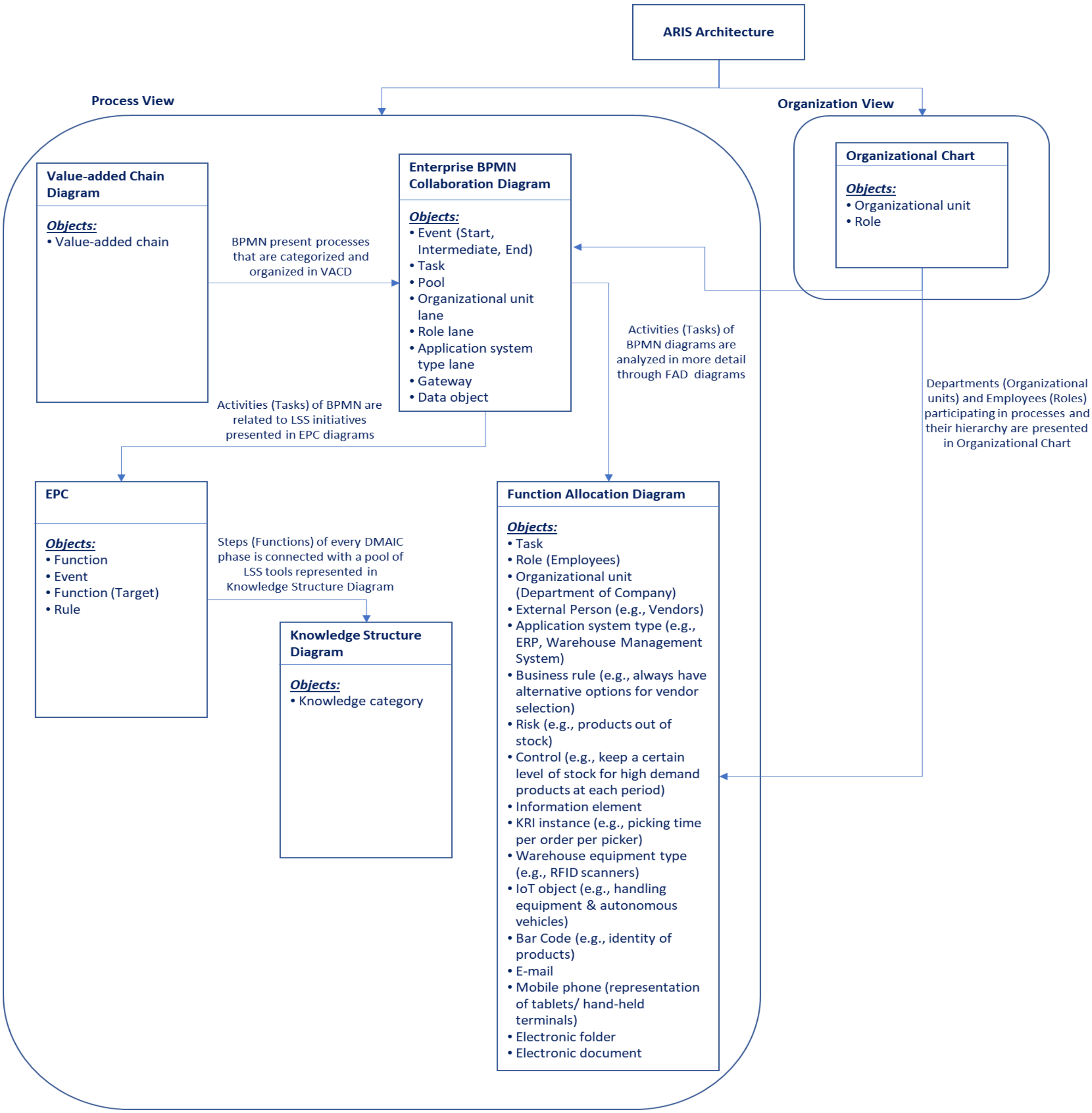


Figure 4.5. ARIS Architecture used for the construction of the LSS RSCPR

The total number of the diagrams configurated for the LSS RSCPR was 53, 19 of which were Enterprise BPMN Collaboration Diagrams including 248 activities (from which 35 are related to 61 LSS initiatives in total), 16 FAD, 15 EPC, one VACD, one Organizational Chart and one KSD. Each BPMN diagram, apart from the respective FAD diagrams that explain activities in more detail, is accompanied by explanation text following a specific rigorous template for the descriptions of all the steps of processes and their components. Each EPC diagram is also accompanied by a description text which shows how the steps of DMAIC can be implemented for each LSS initiative and explains which tools are appropriate to be utilized depending on the data that were collected and the problem that is going to be confronted.

For the guiding throughout the reference model a data dictionary with the objects that were used, and their description id presented in **Appendix A1.1**. In addition, in **Appendix A1.2** the **Figure** of the organizational chart that depicts the structure of the departments and the employees' positions that were used in the LSS RSPR is presented.

4.3 Retail Supply Chain Processes

The retail supply chain processes that were configured under the guidance of participating companies cover the operations from purchasing of merchandise to delivery to stores. **Figure 4.6** depicts the hierarchy of the business processes of the LSS RSCPR in the form of a VACD.

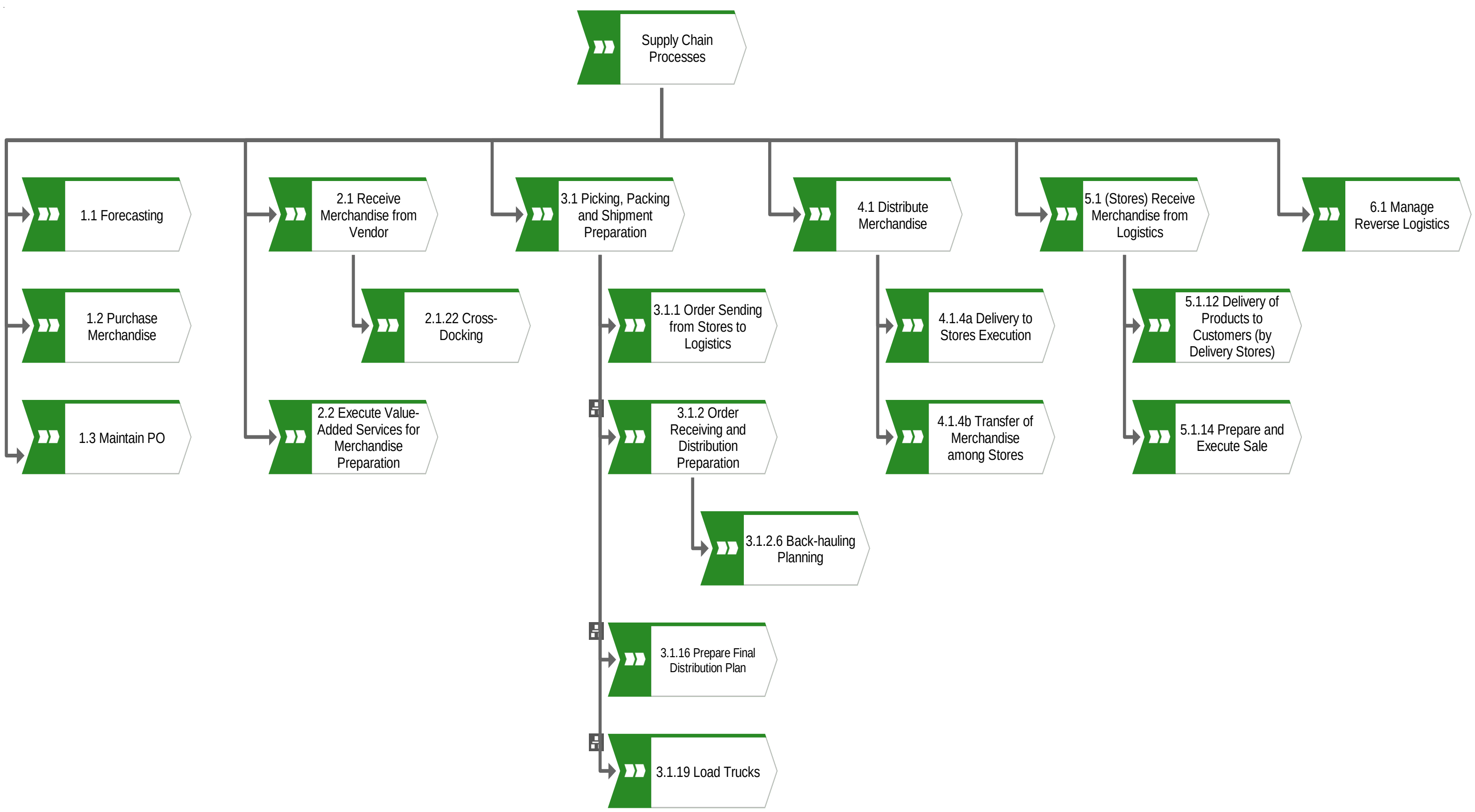


Figure 4.6. Tree of processes included in the LSS RSCPR

As shown by **Figure 4.6**, there are three levels of processes. The levels of decomposition of each business process depend on the level of detail needed for the representation of the activities that were judged to be important and should be included in the model. **Table 4.2** includes the processes depicted in the VACD of Figure 4 providing further information about the involved participants, a short description of each process, the number of activities contained in them and the number of activities recognized as candidates for LSS initiatives. The biggest proportion of the processes concern logistics operations as it is the most important part of supply chain (Sachan and Datta, 2005), being the link to connect all its components together (Christopher, 2016). In logistics processes, the retail companies of our research detected the most opportunities for improvements.

Table 4.2. Presentation of the structure and description of the processes included in the RSCPR

Process/ Subprocess	**Participants**	**Number of activities/ Number of activities with LSS initiatives**	**Description**
1.1 Forecasting	Department of Merchandising	6/ 1	Calculation of sales and demand forecasting for more accurate merchandise purchasing
1.2 Purchase Merchandise	Department of Merchandising, Vendor	12/ 2	Sending of Purchase Order (PO) to vendor according to the needs of replenishment
1.3 Maintain PO	Department of Merchandising	6/ 1	Tracking, reviewing, and managing POs in the Information System used.
2.1 Receive Merchandise from Vendor	Department of Logistics, Stores, Vendor	40/ 11	Management of the incoming flow from the receipt to the storage or the decision for cross-docking. It is separated in two different flows based on whether the merchandise is received by the Distribution Center (DC) or stores according to the contract made with vendor.
2.1.22 Cross-Docking	Distribution Supervisor, Loading Supervisor, Loading Employees, Planning Manager, Vendor	19/ 4	Description of the steps of the cross-docking process including the arrangement of merchandise receipt with the vendor and the preparation and execution of the cross-transfer of merchandise
2.2 Execute Value Added Services for Merchandise Preparation	Department of Logistics	4/ -	Acquisition of materials needed for packaging (e.g. cartons) and generating tags of merchandise
3.1 Picking, Packing and Shipment Preparation	Department of Logistics, Stores	19/ 3	Description of the planning and execution of picking and packing

Process/ Subprocess	Participants	Number of activities/ Number of activities with LSS initiatives	Description
			processes in order to get products prepared for loading
3.1.1 Order Sending from Stores to Logistics	Store Manager	8/ 1	Order placement by stores to the ERP system based on its needs in order to be prepared and sent by the DC
3.1.2 (DC) Order Receiving and Distribution Preparation	Planner, Distribution Supervisor, Shift Supervisor, Planning Manager	18/ 1	Receipt of store orders and planning of the primary distribution plan according to them, including back-hauling and unplanned events
3.1.2.6 Back-hauling Planning	Distribution Supervisor, Planner, Planning Manager	9/ 1	Description of the back-hauling process planning where the trucks transferring merchandise from DC to Stores make intermediate stops in the return to collect contracted merchandise from vendors being easily accessible on the returning route and transfer it to DC
3.1.16 Prepare Final Distribution Plan	Loading Supervisor, Planner, Planning Manager	8/ 1	Presentation of planning and preparation of final distribution plan which determines the trucks that will be used for each order and the time of delivery to stores. This plan is configured after picking/ packing completion
3.1.19 Load Trucks	Shift Supervisor, Loading Supervisor, Loading Employee	18/ 2	Analysis of the activities that should be accomplished for the loading of trucks with merchandise (pallets) including the assignment of trucks to loading lanes, creation of loading documents and preloading preparation activities for the next shift

Process/ Subprocess	Participants	Number of activities/ Number of activities with LSS initiatives	Description
4.1 Distribute Merchandise	Department of Logistics	5/ 1	Representation of the preparation and execution of merchandise distribution to stores consisting of creating shipment documentation, delivering to stores activities and shipment recording activity
4.1.4a Delivery to Stores Execution	Shift Supervisor, Logistics Accounting Department, Driver	12/ -	Description of the activities that the driver and the store manager should do for the delivery and the receipt of merchandise respectively
4.1.4b Transfer of Merchandise among Stores	Planning Manager, Distribution Supervisor, Store	7/ -	Description of the special occasions when there is a need for transferring of merchandise among stores and need permission by the planning manager in order to be added to the distribution plan
5.1 (Stores) Receive Merchandise from Logistics	Department of Logistics, Stores	15/ -	Presentation of the activities that should be executed from the store for the receipt, unloading, storage, and transferring of products to be placed on selling floor/ shelves
5.1.12 Delivery of Products to Customers (by Delivery Stores)	Sales Department Employee, Store Employee, Delivery Driver	11/ -	Executing delivery of online orders from delivery stores to customers (elaboration of online orders through CRM system, preparation of products and delivery documentation, scheduling of delivery, recording of shipment status, delivery execution)
5.1.14 Prepare and Execute Sale	Store Manager, Store Employee, Cashier	18/ 4	Description of products replenishment and placement on specific places in store, selling of products and connection of sales with forecasting and ERP system

Process/ Subprocess	Participants	Number of activities/ Number of activities with LSS initiatives	Description
			for auto-order or with vendors' ERP (Vendor Managed Inventory-VMI), if the products are auto-replenished by vendor
6.1 Manage Reverse Logistics	Department of Logistics, Department of Merchandising, Stores	13/ 2	Receiving returned or defective products and making the decision of their management (e.g., returning to vendor, donation to charities, disposal)
		Total: 248/ 35	

The model includes three levels of processes. The first level is in the form of X.X (e,g,, 1.1, 2.1) and includes the participant in the most general level of Department. The second level is in the form of Y.Y.Y (e.g., 2.1.22, 3,1,2) and the third level is in the form of Z.Z.Z.Z (e.g., 3.1.2.6). Both of these levels are modeled including participants in the level of Role (e.g., Distribution Supervisor, Planner). In addition, the numbering of the second level comes from the activities of the first level. For example, the process 2.1.22 is more low-level and detailed depiction of the activity 22 (or 2.1.22 as numbered in the model) of the 2.1 process. The third level was used in specific cases where the an activity of a second-level process needed a more detailed analysis. For example, process 3.1.2.6 refers to the activity 6 (or 3.1.2.6 as numbers in the model) of the process 3.1.2. In the next pages the diagrams of the retail supply chain processes that were modeled are presented. The activities with the blue colour are proposed for LSS initiatives and they are connected with the diagrams of LSS improvement areas.

Process 1.1: Forecasting

Date of First Version: 16/01/2021

Date of Final Version: 17/05/2021

Aim of the Process: Determination and execution of sales forecasting for efficient and accurate merchandise replenishment.

Process Owner: Department of Merchandising

Editor: Konstantinos Stergiou

1.1. Forecasting

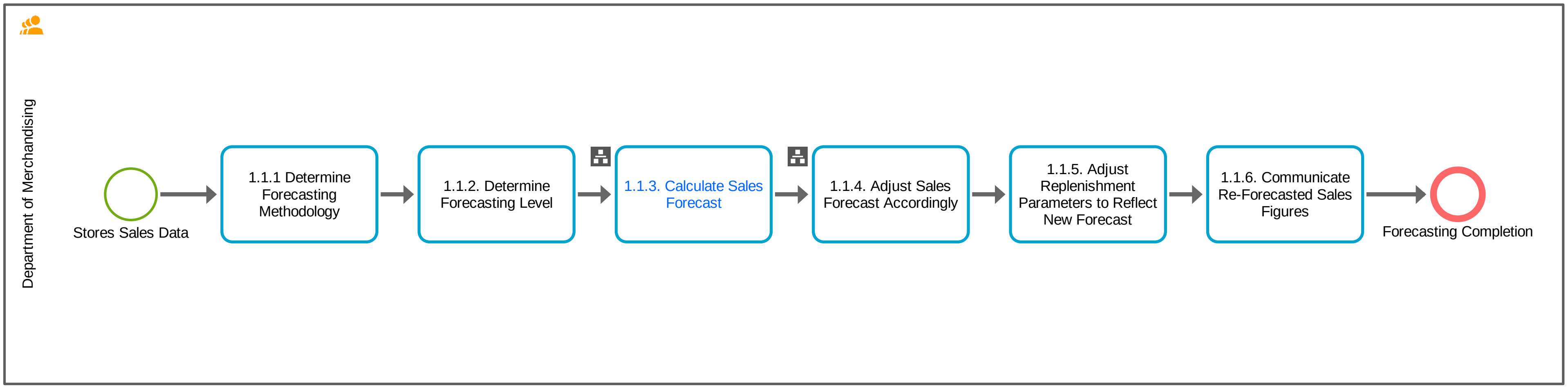


Figure 4.7. Forecasting Process (1.1)

4.3.1.1 Process Prerequisites

- Existence of sales data and information needed for forecasting

4.3.1.2 Process Participants

- Department of Merchandising

4.3.1.3 Periodicity of the process

- Depends on each company’s operations

4.3.1.4 Process Description

Department of Merchandising decides the methodology that will be used for forecasting. Factors taken under consideration are store’s trend to previous year; store’s performance to plan; or a most recent weekly sales trend basis. Other factors to consider are improvements in stores that will increase opportunities, changes in competitive environment, etc.

Then the Department of Merchandising choose the level of forecasting. A forecast can be done at the department level, thereby incorporating all items, or it can be drilled down to a category level, item level, etc. Some forecasts are performed at the order level for each item included in the order.

Calculating sales forecast follows the two aforementioned steps. In this step, the Department of Merchandising should take under consideration current sales trend as well as any known future activities/promotions that will impact sales and utilize appropriate technology. The usage of contemporary forecasting information systems is recommended for the automated and direct calculation of forecasting figures.

The data provided by the system are adjusted by the Department of Merchandising according to unexpected needs of sales. Subsequently, the replenishment parameters should be adjusted based on system forecasts. For example, back-to-school season leads to increase of the sales of school supplies. It may be necessary to adjust replenishment models to eliminate out of stock problems on all items.

Finally, the re-forecasted sales figures should be communicated through the Department (physically or systemically) as a driver for purchasing (Process *1.2 Purchase Merchandise*).

4.3.1.5 Documents

-

4.3.1.6 Information Systems

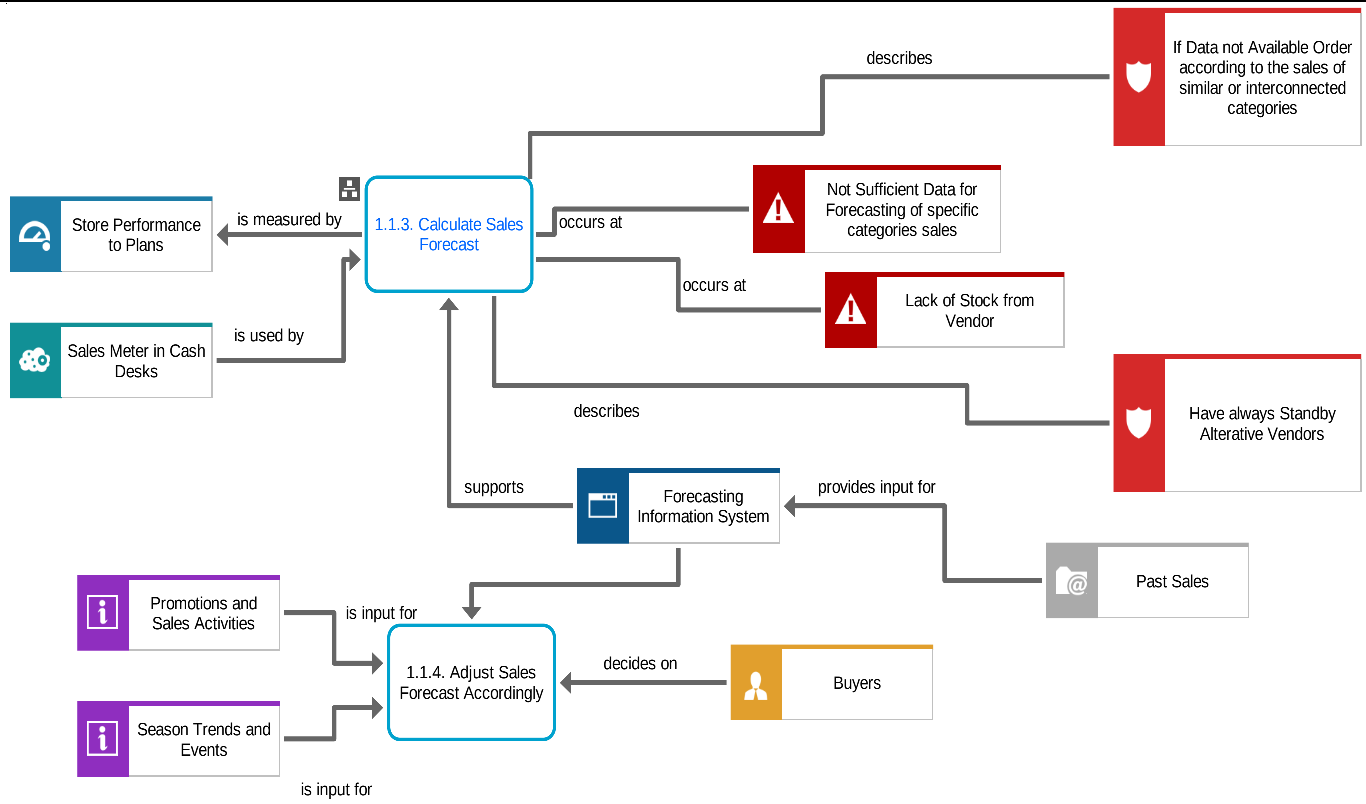
- Forecasting Information System

4.3.1.7 Linked Processes

- 1.2 Purchase Merchandise

4.3.1.8 Supplementary Diagrams

Table 4.3. Supplementary Diagrams for Forecasting Process (1.1)

Activity	Function Allocation Diagram
1.1.3 Calculate Sales Forecast 1.1.4. Adjust Sales Forecast Accordingly	

Process 1.2: Purchase Merchandise

Date of First Version: 16/01/2021

Date of Final Version: 04/05/2021

Aim of the Process: Determination of the right order quantity along with the preparation and sending of Purchase Orders (PO) to Vendor.

Process Owner: Department of Merchandising

Editor: Konstantinos Stergiou

1.2. Purchase Merchandise

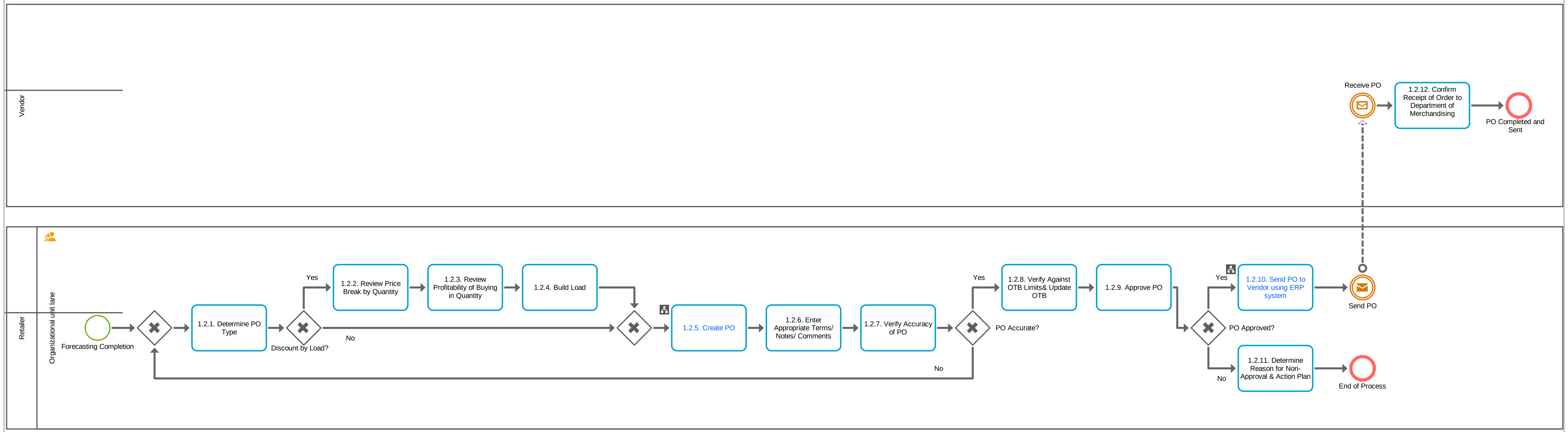


Figure 4.8. Purchase Merchandise Process (1.2)

4.3.2.1 Process Prerequisites

- Execution of Forecasting

4.3.2.2 Process Participants

- Department of Merchandising

4.3.2.3 Periodicity of the process

- Depends on each company's need for replenishment

4.3.2.4 Process Description

Department of Merchandising determines the PO type. For example, a blanket PO refers to a single order for quantity of merchandise to be delivered over time. A recurring PO is a purchase order that is always valid and can be delivered against. A standard PO is usually for a defined ship date with specified terms. Then, the Department check the quantity of merchandise that should be ordered. The decision is received by reviewing price reductions owing to the order of big bulks and what is the profitability of buying big quantities. For this decision is important shelf-life of product, merchandise handling and consumer demand (forecasting) to be taken under consideration. Department of Merchandising should also build the load by calculating how many pallets (boxes) can be transferred by a fully loaded truck, because it is possible that Vendors will offer price discounts based on load building (e.g., a full truckload may cost less than a half truckload).

After this elaboration, the Department of Merchandising creates the PO and enters the appropriate terms/ notes/ comments like the cost and retail prices of the items being ordered along with a total for all items on the order. Important notes to the DC should be added to the PO (e.g., hang items/fold items). The next is the verification of the accuracy of the PO to ensure that PO is correct and matches the desired order. If the PO is not accurate then all the previous steps should be executed again. If the PO is accurate then Department of Merchandising (Buyers) should check the amount of money spent against Open-to-buy (OTB is the amount of merchandise that a company can buy in a certain period while maintaining a positive cash flow). If there is the OTB for the order, the OTB must, then, be updated (total amount of money of PO is subtracted from OTB amount). Subsequently, the PO that has been prepared by buyer should be approved by the supervisor, particularly if there is a need of exceeding OTB.

If the PO does not get approval, then an action plan should be established for the confrontation of the reasons that were determined, as those which prevented the approval. If the PO is approved, then it is sent to Vendor with the help of ERP (Enterprise Resource Planning) system and the Vendor mut send a confirmation that the PO has been received. The PO is maintained and archived in the ERP (Process *1.3 Maintain PO*)

4.3.2.5 Documents

- (Electronic) Purchase Order (Cost, Quantity, Discounts, Day of Delivery, Place of Delivery)

4.3.2.6 Information Systems

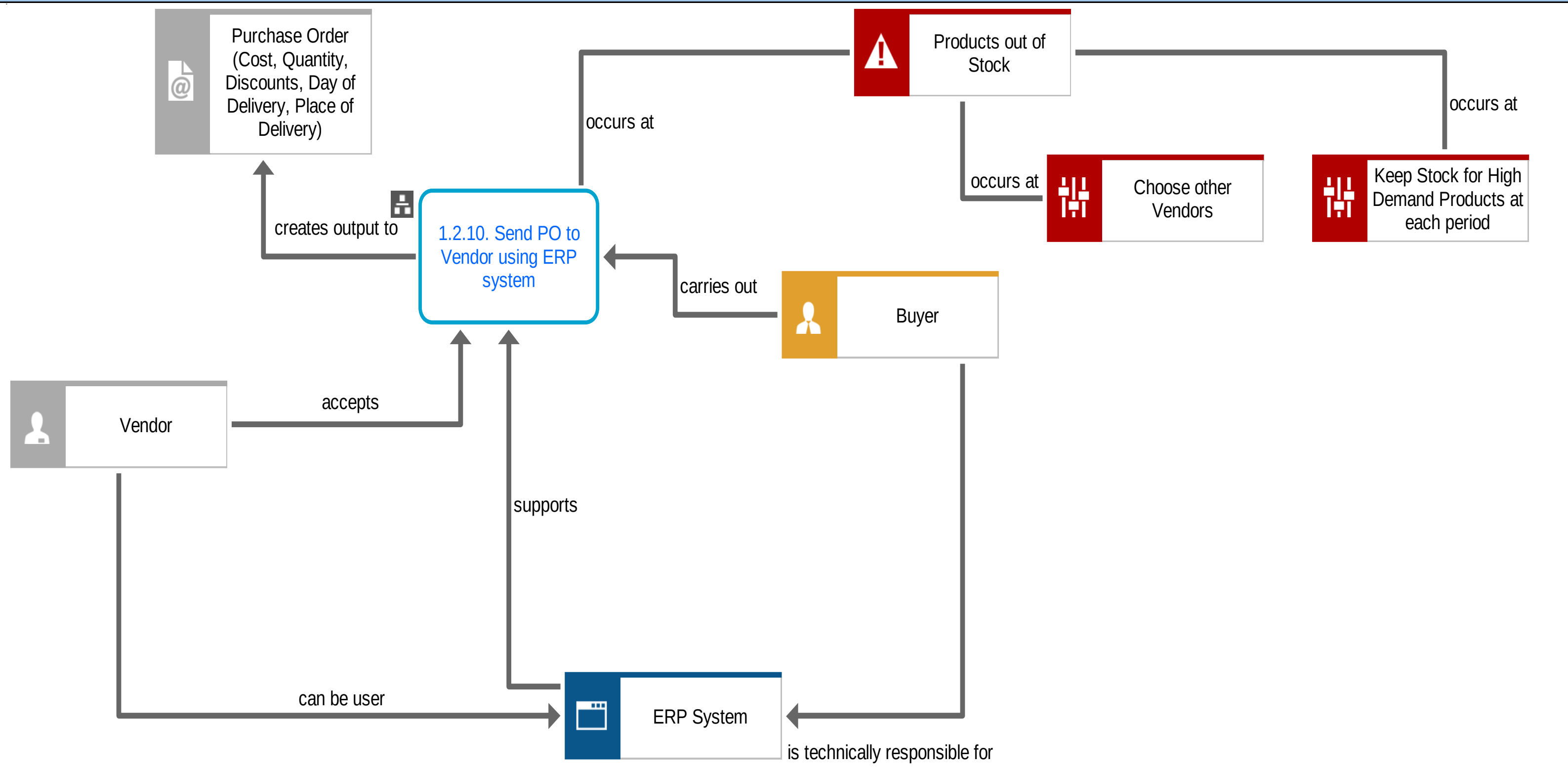
- ERP system

4.3.2.7 Linked Processes

- 1.3 Maintain PO

4.3.2.8 Supplementary Diagrams

Table 4.4. Supplementary Diagrams for Purchase Merchandise Process (1.2)

Activity	Function Allocation Diagram
1.2.10 Send PO to Vendor using ERP system	

4.3.3 Maintain Purchase Order Process (1.3)

Process 1.3: Maintain PO

Date of First Version: 16/01/2021

Date of Final Version: 04/05/2021

Aim of the Process: Tracking, reviewing and management of the Purchase Orders (PO) that have been sent to Vendor.

Process Owner: Department of Merchandising

Editor: Konstantinos Stergiou

1.3. Maintain Purchase Order

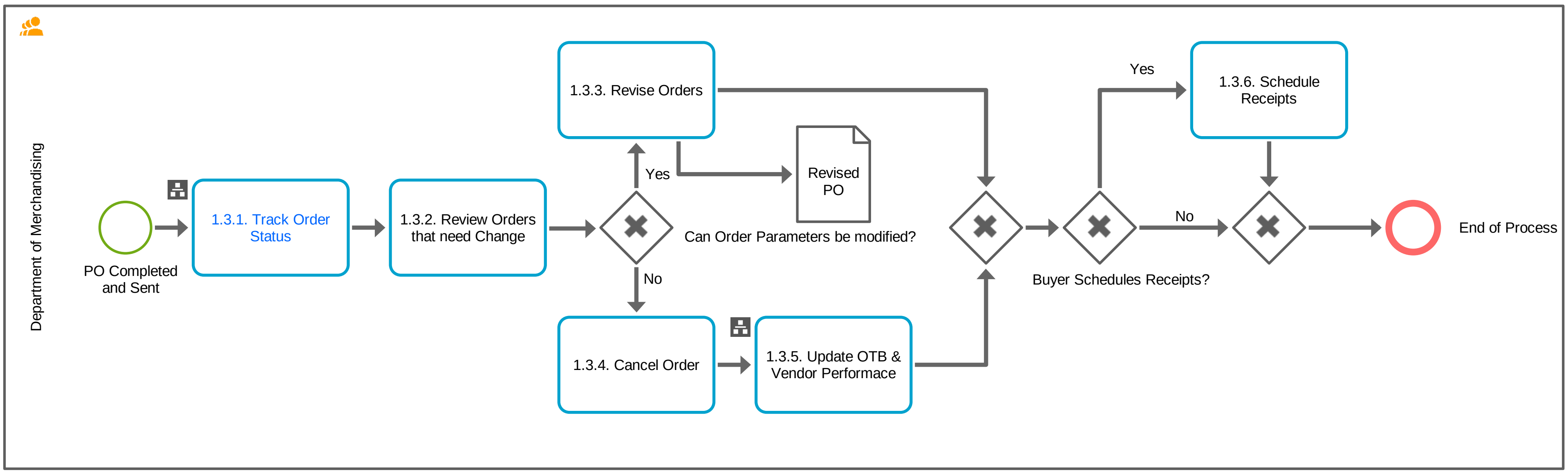


Figure 4.9. Maintain Purchase Order Process (1.3)

4.3.3.1 Process Prerequisites

- Existence of sent PO

4.3.3.2 Process Participants

- Department of Merchandising

4.3.3.3 Periodicity of the process

- Every time there are active PO (Continually)

4.3.3.4 Process Description

The Department of Merchandising continually tracks order status so that can accurately project sales, markdowns and OTB. The Department also tracks orders containing advertised items so they can offer substitute items if the advertised items are late, or so they can cancel an ad. Order status types include late, in-transit, open, etc. The Department reviews the PO to examine if there is a need for revisions. The appropriate revision and changes are made in items, prices, delivery dates, etc., if there are issues with Vendors (e.g., lack of availability for specific items). If the changes cannot be made, then the order is cancelled by the Department and the OTB is updated so that the order can be replaced if necessary. Also, vendor performance needs to be updated to ensure accurate tracking of Vendor's KPIs. Finally, there are cases where the usual practice that the Vendor schedule appointments for delivery with the retailer's Distribution Centers, is detoured. There are times when the buyers of the Department of Merchandising track the PO and need to schedule the delivery in order to expedite the order to stores. This happens often with promotional/advertised items. If the Buyer of the Department of Merchandising is not in charge of schedule receipts, then the process ends.

4.3.3.5 Documents

- Revised PO

4.3.3.6 Information Systems

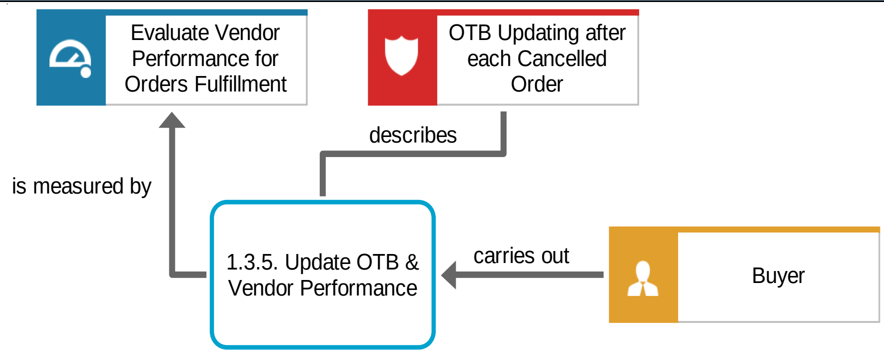
- ERP system

4.3.3.7 Linked Processes

-

4.3.3.8 Supplementary Diagrams

Table 4.5. Supplementary Diagrams for Maintain Purchase Order Process (1.3)

Activity	Function Allocation Diagram
1.3.5. Update OTB & Vendor Performace	

4.3.4 Receive Merchandise from Vendor Process (2.1)

Process 2.1: Receive Merchandise from Vendor

Date of First Version: 17/01/2021

Date of Final Version: 18/04/2021

Aim of the Process: Receipt of merchandise by Department of Logistics or Stores and the management of received merchandise by the distribution center.

Process Owner: Department of Logistics

Editor: Konstantinos Stergiou

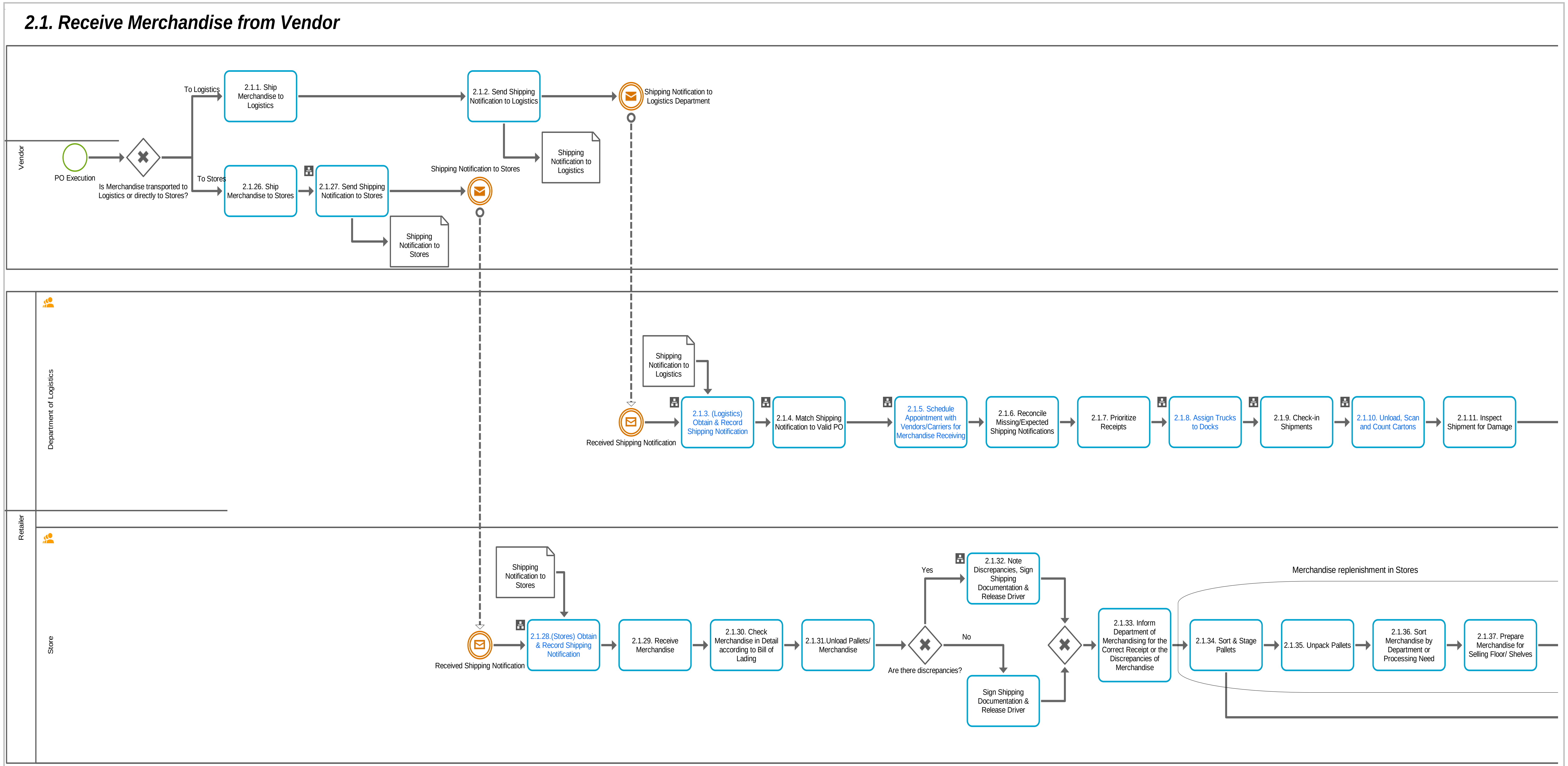
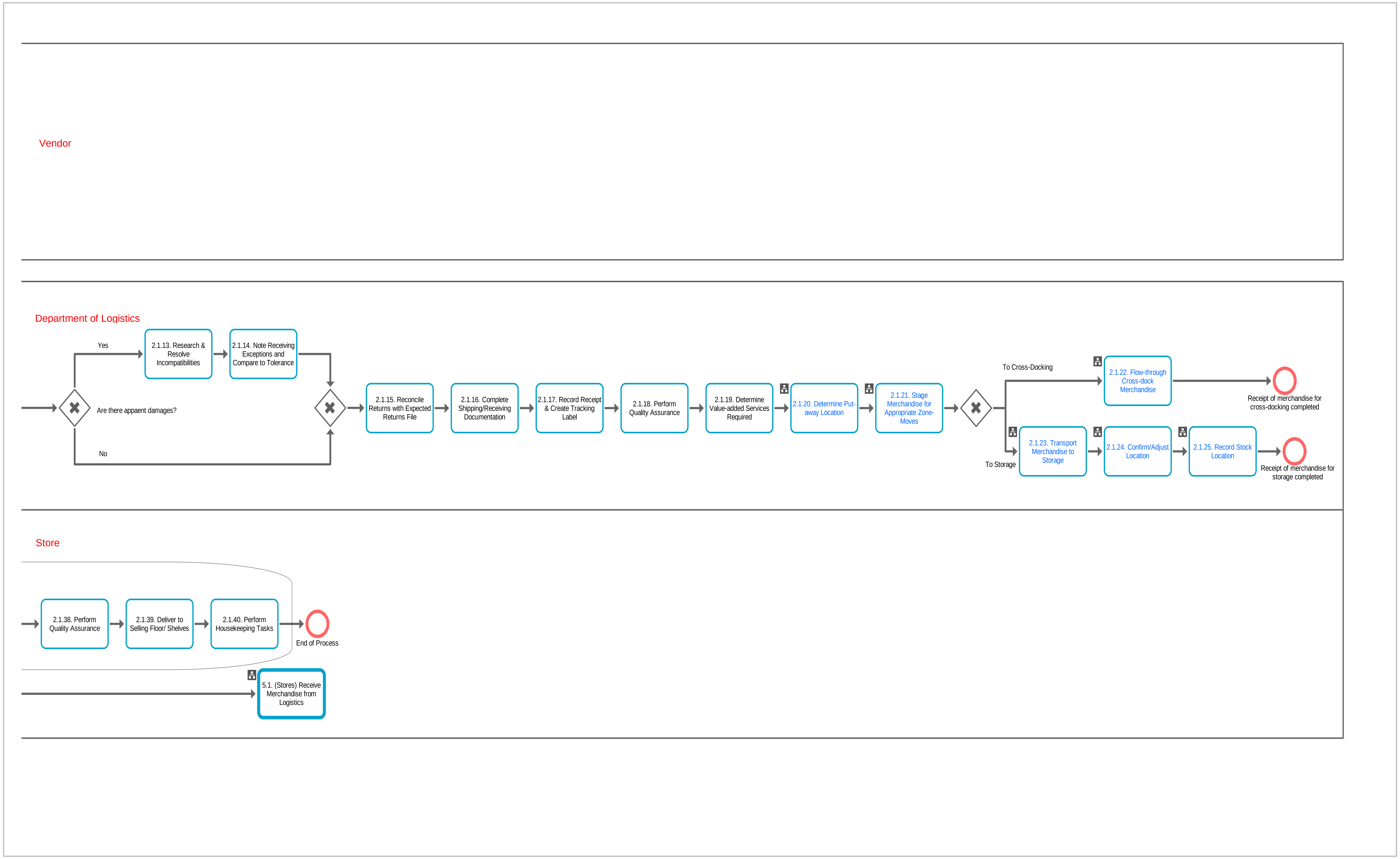


Figure 4.10. Receive Merchandise from Vendor Process (2.1)


Vendor
Department of Logistics
Yes
2.1.13. Research & Resolve Incompatibilities
2.1.14. Note Receiving Exceptions and Compare to Tolerance
Are there appaent damages?
No
2.1.15. Reconcile Returns with Expected Returns File
2.1.16. Complete Shipping/Receiving Documentation
2.1.17. Record Receipt & Create Tracking Label
2.1.18. Perform Quality Assurance
2.1.19. Determine Value-added Services Required
2.1.20. Determine Put-away Location
2.1.21. Stage Merchandise for Appropriate Zone-Moves
To Cross-Docking
2.1.22. Flow-through Cross-dock Merchandise
Receipt of merchandise for cross-docking completed
To Storage
2.1.23. Transport Merchandise to Storage
2.1.24. Confirm/Adjust Location
2.1.25. Record Stock Location
Receipt of merchandise for storage completed
Store
2.1.38. Perform Quality Assurance
2.1.39. Deliver to Selling Floor/ Shelves
2.1.40. Perform Housekeeping Tasks
End of Process
5.1. (Stores) Receive Merchandise from Logistics

4.3.4.1 Process Prerequisites

- Execution of PO by Vendor
- Ability of Vendor to send Shipping Notification through integrated IS

4.3.4.2 Process Participants

- Department of Logistics
- Stores
- Vendor

4.3.4.3 Periodicity of the process

- On a daily basis

4.3.4.4 Process Description

The process starts with the shipping of merchandise by Vendor to the Logistics of Retailer or to Stores if the agreement includes direct to store delivery. Depending on the destination of shipment the Vendor should sent (electronically) a shipment notification with all the details of the products that are included in the shipment.

In the case of Stores, the shipment notification can be used for tracking of the shipment by ERP system in order to know when exactly the merchandise will arrive. When the truck with merchandise arrives to the Store the merchandise is checked in detail according to the order that has been made and the Bill of Lading. Then the merchandise (pallets/ boxes) is unloaded for the checking of its quantity and condition. If there are discrepancies in received order, in comparison with the shipment documents, then the Store keeps the received products that are ok and should inform Department of Merchandising to take the appropriate actions. If the received order is ok, then the Store just informs the Department of Merchandising for the completion of the receipt. The next moves concern the preparation of merchandise to be sold by the Store. The pallets/ boxes are sorted and staged for delivery to selling floor. Then, the unpacked and the contained products are sorted depending on the section of store that should be transferred for replenishment. Appropriate tasks such as assembly or folding, applying merchandise supplies such as security tags, size indicators or hangers are carried out. In particular, for food retail operations must be ensured that perishable products are prepared in accordance with the policy and sanitation standards and should be assured that grocery/non-food products are stored and processed as necessary. After the completion of preparation, the quality of products must be assured by checking all the details that ensure a product fulfill the specifications and has no defects. This quality assurance activity is the enabling factor for delivering the products to selling floor and stage them or place them to shelves. In food retail operations perishable products should be staged and placed in accordance with sanitation and policy standards. Finally, the receiving area must be cleaned and maintained organized for the next receipts and preparations of products to be delivered on the sell floor. In food retail operations all freezers, equipment and storage areas of all sections must be maintained.

In the case of merchandise received by the DC, the Department of Logistics receives the shipping notification by the Vendor for the tracking of the incoming order using ERP system. The recording and tracking of each incoming order is occurred by the matching of shipping notification with the corresponding PO. This matching of quantities/products will help in the identification any potential discrepancies and will speed up product flow once the merchandise has been received at the facility. The Department of Logistics also schedules appointment for receipt of goods based on communication from vendor/carrier and expected receipts. The Department of Logistics should reconcile missing or expected shipping notifications in order to know all the information needed for the expected incoming shipments (if a shipment arrives without shipment notification and paperwork, then Department of Logistics can reject it or do not proceed to unloading, until necessary documents and notifications receipt.) After the shipping notifications receipt, the Department of Logistics have to prioritize receipts according to special handling requirements, promotion products, and customer-expected fill rate. Then, the Department of Logistics should assign trucks to specific docks in order to facilitate the process of unloading according to the handling requirements of merchandise.

When the truck arrives to the warehouse, the WMS and employees must be informed for the check-in. Then, the employees of the Department of Logistics open trailer, unload and scan or count cartons to match against shipping documentation. This activity can be accomplished in various ways and is based totally on the material handling automation at the point of receiving within the facility. This activity may be manual or automated through the usage of advanced warehouse management systems and equipment (RF-Radio Frequency scanners, RFID, autonomous unloading machines). If the shipment does not match the PO, then the products are transferred to a “trouble area” for reconciliation. If the shipment matches the PO, then employees of Logistics inspect products for damages. There are two levels of merchandise rejection to take into account: (1) the shipment was too damaged to continue unloading and must be returned, (2) only a portion of the merchandise was damaged or deemed unacceptable and will be moved to the “trouble” area for future return to vendor. For the problems that were identified in the matching of shipments, the Department of Logistics should resolve discrepancies, note them on shipment documentation and compare them against tolerance. This information should be recorded in vendor compliance file (the recording of discrepancies is particularly important to be occurred before the truck leaves the dock). After that, the employees of Department should check the returns file to find if there are returns (from stores) that should be sent back to Vendor. The final step of the receipt of merchandise is the completion and signing of shipment documentation by the Department employees and releasing of driver.

Each case/pallet received must be “traceable” within the facility. So, it must be “declared” in the WMS by the Department of Logistics after the receipt is completed and before storage, utilizing the appropriate tagging warehouse equipment (barcode, RFID, IoT sensors). After the tagging of merchandise, the quality of it has to be assured. Based on established guidelines (from vendor profiles), merchandise quantity and quality checks are performed on specific orders or percentages of each order. If the organization has an established Vendor Performance Program, defined rules will govern the type of quality inspection required. After the quality assurance, the Department must determine the value-added services required for providing store-floor-ready merchandise (Process 2.2). Then, the Department determines the put-away location of merchandise according to the flow that will follow. The ultimate location may be cross-docked directly into an outbound trailer (Process *2.1.22. Cross-Docking*), storage into reserve location or directly into a forward pick location (Process *3.1. Picking, Packing and Shipment Preparation*). After the determination of the put-away location, the merchandise is temporarily staged for the next final zone-moves. Received merchandise must be moved away from the receiving dock as quickly as possible by the employees of Department of Logistics. Advanced material handling equipment such as automated conveyors may eliminate the need to stage product and AR applications can quickly lead DC employees to find the appropriate location. If products are intended for storage, then they transported in their final location that has been determined from the previous. The confirmation of the correctness of location follows. If there is a problem (slot full, wrong location), the slot location must be adjusted. Otherwise, the merchandise is placed to slot. The final step of storage is the assurance that the stock location is recorded in WMS (RFID, IoT objects that communicate with warehouse vehicles and WMS). If the received merchandise is programmed for cross-docking, then it is moved/transferred directly for shipping preparation.

4.3.4.5 Documents

- Shipping Notification to Logistics
- Shipping Notification to Stores
- Shipping Documentation

4.3.4.6 Information Systems

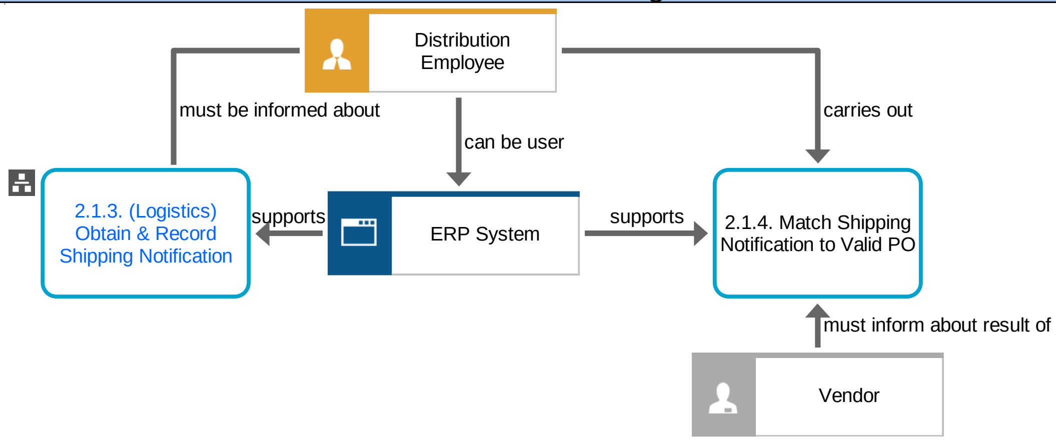
- ERP system
- WMS

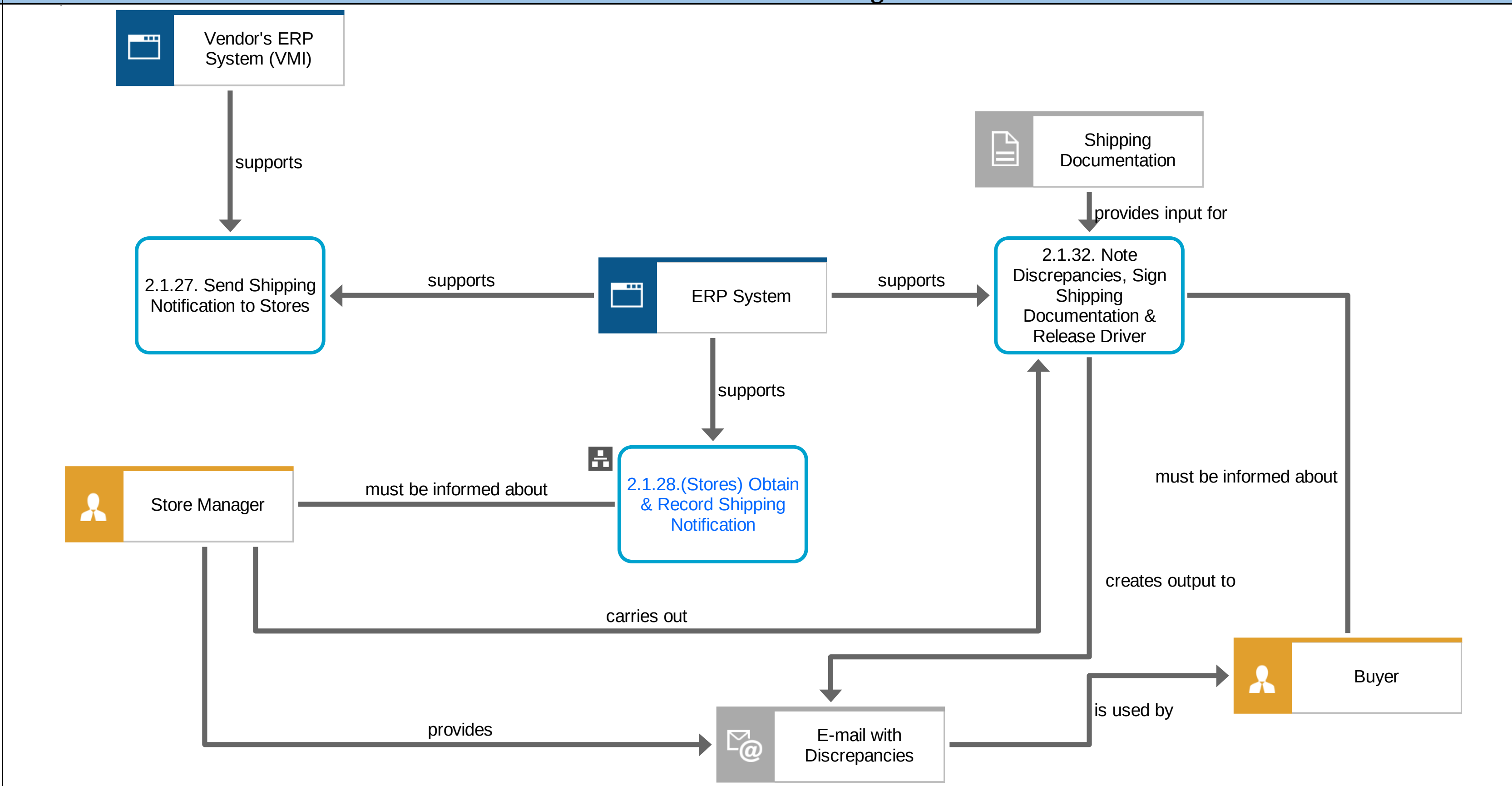
4.3.4.7 Linked Processes

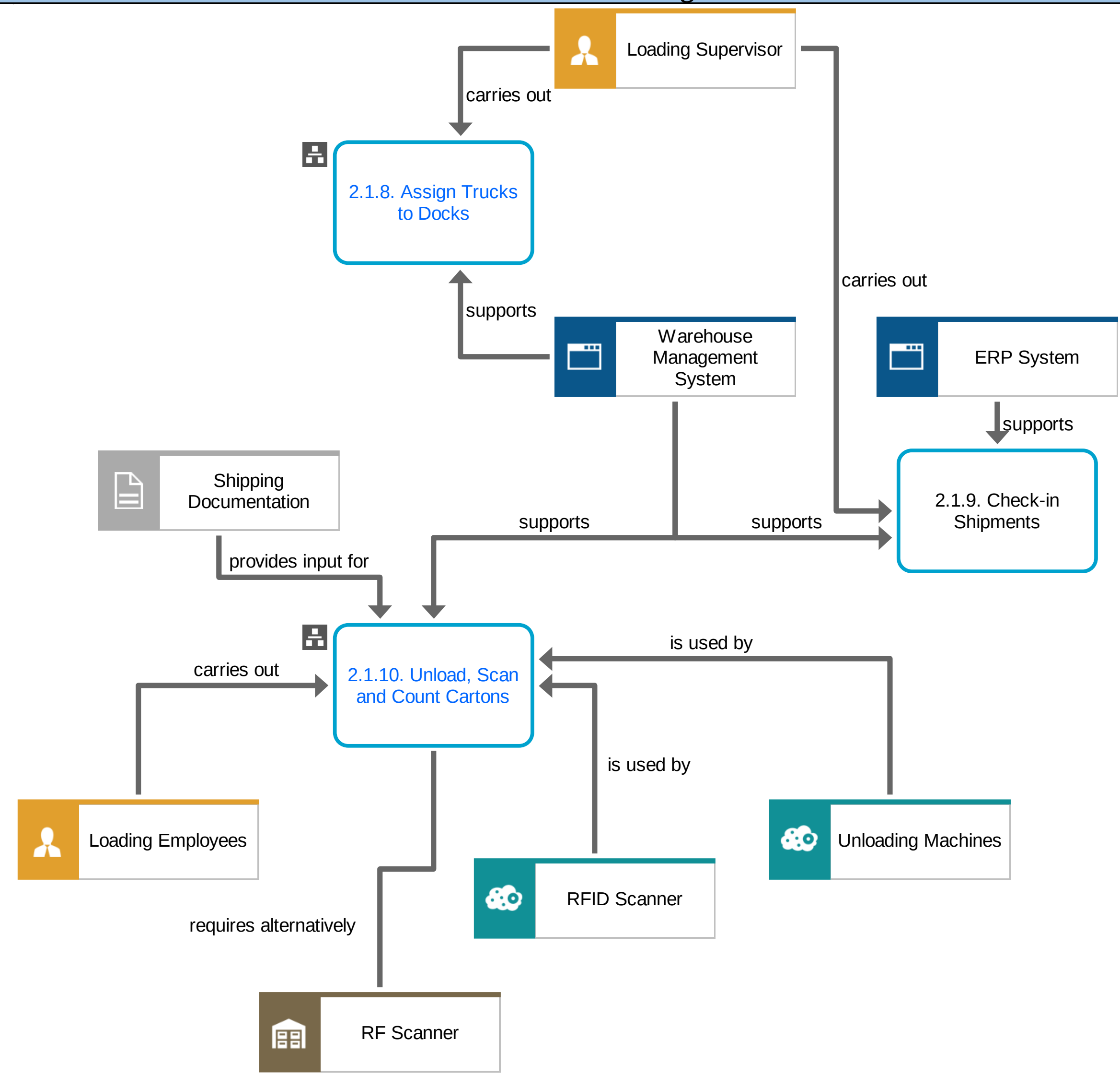
- 2.1.22. Cross-Docking
- 3.1. Picking, Packing and Shipment Preparation

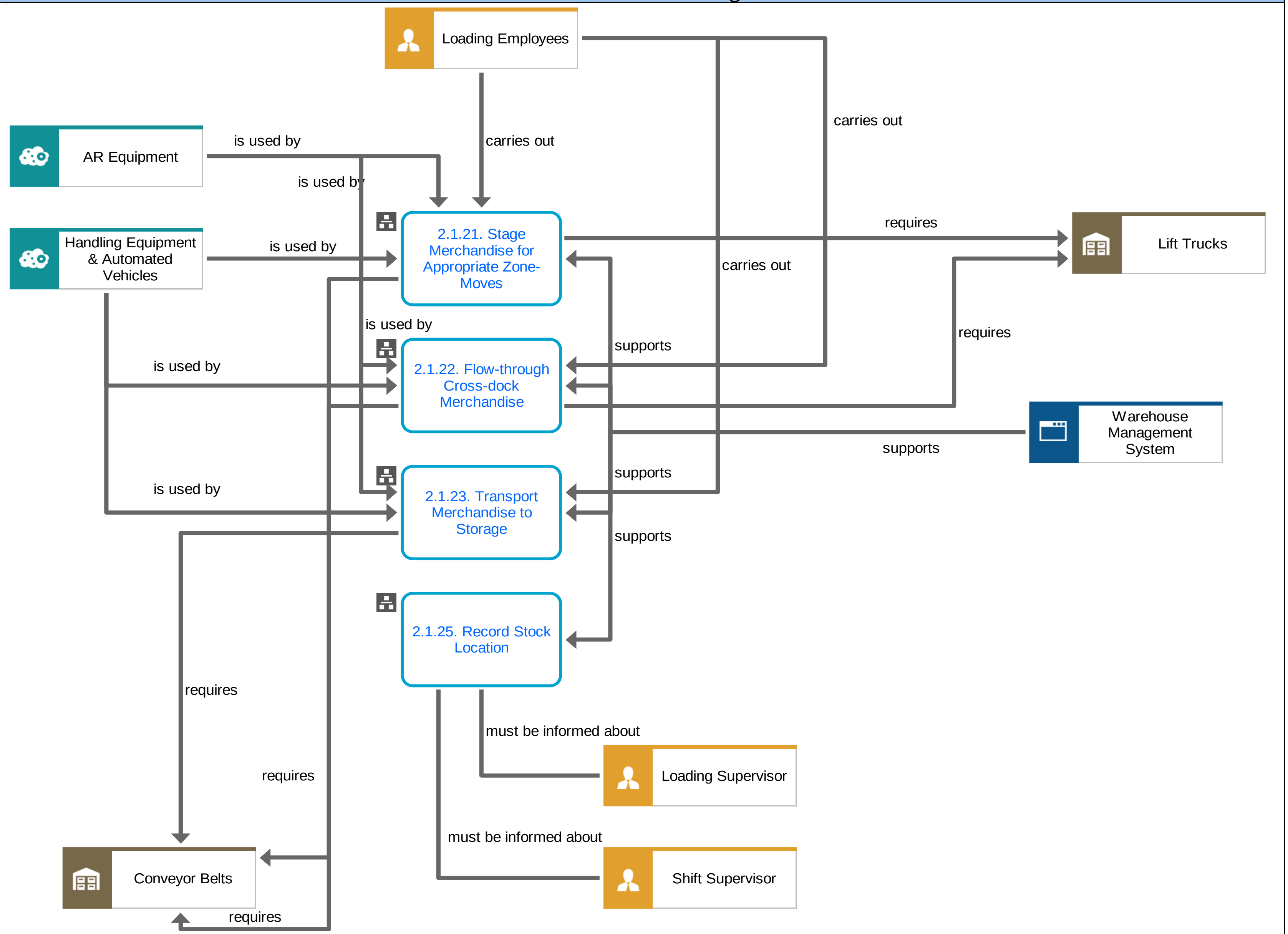
4.3.4.8 Supplementary Diagrams

Table 4.6. Supplementary Diagrams for Receive Merchandise from Vendor Process (2.1)

Activity	Function Allocation Diagram
2.1.3. (Logistics) Obtain & Record Shipping Notification 2.1.4. Match Shipping Notification to Valid PO	

Activity	Function Allocation Diagram
2.1.27. Send Shipping Notification to Stores 2.1.28.(Stores) Obtain & Record Shipping Notification 2.1.32. Note Discrepancies, Sign Shipping Documentation & Release Driver	

Activity	Function Allocation Diagram
2.1.8. Assign Trucks to Docks 2.1.9. Check-in Shipments 2.1.10. Unload, Scan and Count Cartons	

Activity	Function Allocation Diagram
2.1.21. Stage Merchandise for Appropriate Zone-Moves 2.1.22. Flow-through Cross-dock Merchandise 2.1.23. Transport Merchandise to Storage 2.1.25. Record Stock Location	

Process 2.1.22: Cross-Docking

Date of First Version: 17/01/2021

Date of Final Version: 18/05/2021

Aim of the Process: Preparation and execution of cross-docking for the merchandise that is not stored and transferred directly to stores.

Process Owner: Distribution Supervisor

Editor: Konstantinos Stergiou

2.1.22. Cross-Docking

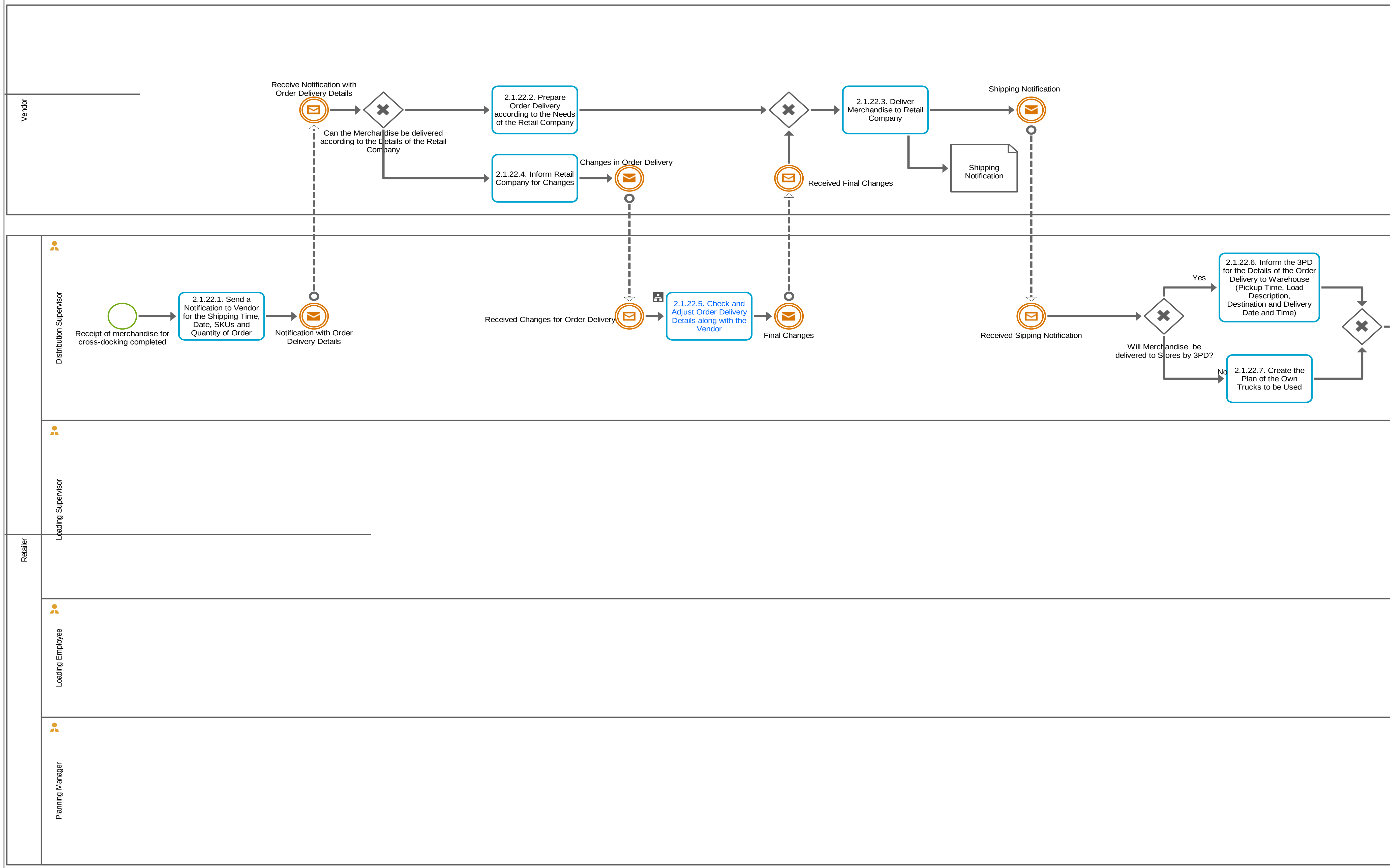
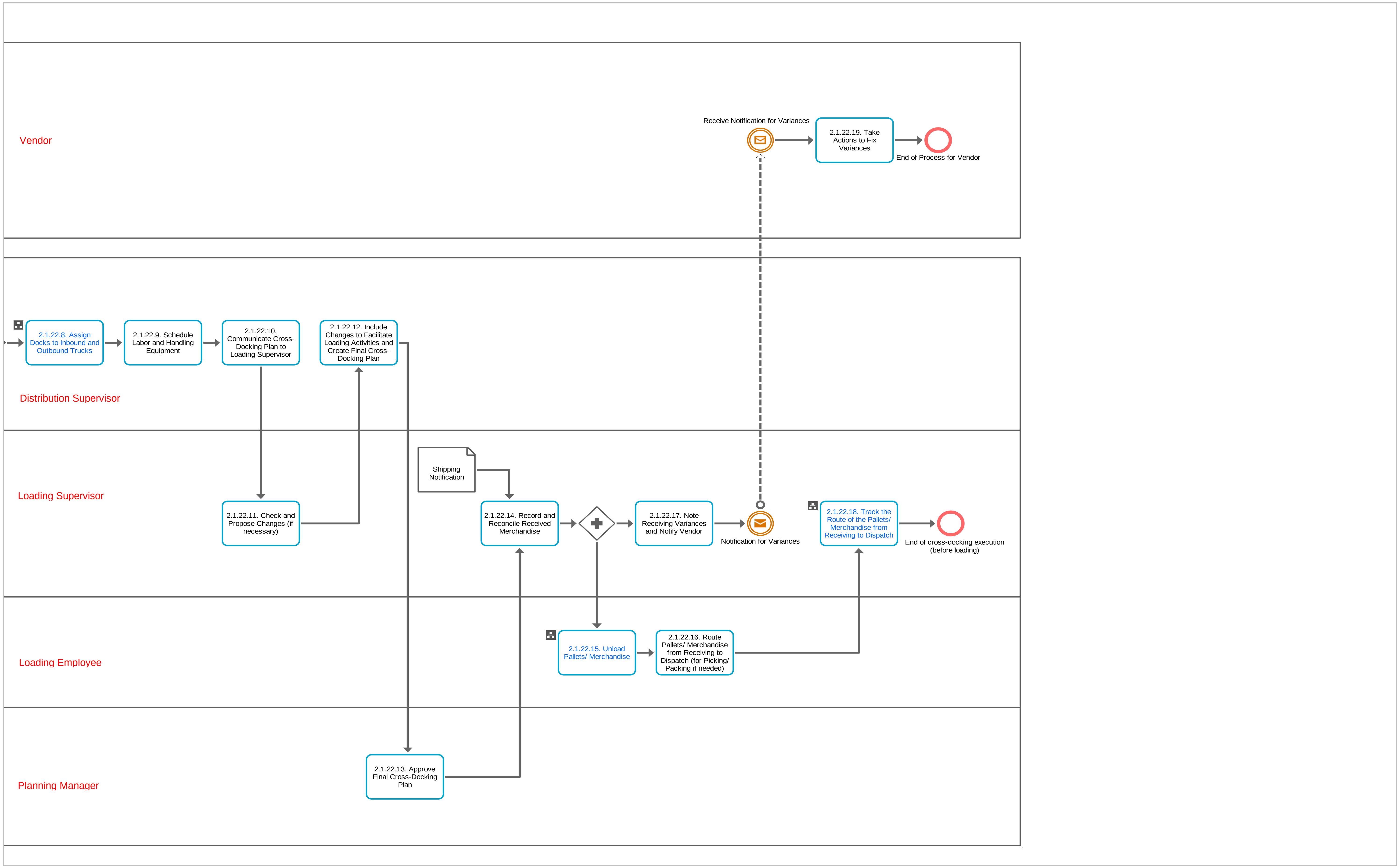


Figure 4.11. Cross-Docking Process (2.1.22)


Vendor
Receive Notification for Variances
2.1.22.19. Take Actions to Fix Variances
End of Process for Vendor
Distribution Supervisor
2.1.22.8. Assign Docks to Inbound and Outbound Trucks
2.1.22.9. Schedule Labor and Handling Equipment
2.1.22.10. Communicate Cross-Docking Plan to Loading Supervisor
2.1.22.12. Include Changes to Facilitate Loading Activities and Create Final Cross-Docking Plan
Loading Supervisor
2.1.22.11. Check and Propose Changes (if necessary)
Shipping Notification
2.1.22.14. Record and Reconcile Received Merchandise
2.1.22.17. Note Receiving Variances and Notify Vendor
Notification for Variances
2.1.22.18. Track the Route of the Pallets/ Merchandise from Receiving to Dispatch
End of cross-docking execution (before loading)
Loading Employee
2.1.22.15. Unload Pallets/ Merchandise
2.1.22.16. Route Pallets/ Merchandise from Receiving to Dispatch (for Picking/ Packing if needed)
Planning Manager
2.1.22.13. Approve Final Cross-Docking Plan

4.3.5.1 Process Prerequisites

- Preparation of Cross-Docking Plan
- Receipt of Merchandise
- Merchandise Unloading

4.3.5.2 Process Participants

- Distribution Supervisor
- Loading Supervisor
- Loading Employees
- Planning Manager
- Vendor

4.3.5.3 Periodicity of the process

- Depends on the needs of merchandise to be cross-docked

4.3.5.4 Process Description

The first step of the process is the notification (through ERP system) of the Vendor by the Distribution Supervisor for the shipping time, date, carrier, stock-keeping units (SKUs), and quantity for each order. Then, the Vendor checks whether can fulfill the requirements of the Retailer or not. If Vendor is capable of fulfilling the Retailers requirements, the merchandise is prepared and delivered, and shipping notification is also sent. If not, then the Vendor informs the Retailer for the changes needed for the delivery. The Distribution Supervisor should communicate with Vendor in order to adjust order delivery details and the Vendor, after the changes, sends the merchandise with shipping notification.

The steps that follow concern the preparation of cross-docking execution. The first step is the communication of the Distribution Supervisor with 3rd party distributors (3PD) for the details of the order delivery to the warehouse (Pickup Time, Load Description, Destination and Delivery Date and Time). If the delivery will occur with retailer trucks, then a plan of the trucks to be used should be prepared. After this communication, the Distribution Supervisor must assign trucks to docks (WMS system) in order to be prepared and facilitate the cross-docking process. Labor and handling equipment is also scheduled by the Distribution Supervisor. The cross-docking plan, including all the aforementioned details, is communicated to the Loading Supervisor and the latter checks it and proposes the necessary changes to keep up with loading requirements. The cross-docking plan, then, is updated by the Distribution Supervisor and is communicated to the Planning Manager for approval. All these activities are taking place before the receipt of merchandise.

When the merchandise is received the Loading Supervisor checks, records, and reconciles the received merchandise according to the details of the shipping notification. If there are variances, they should be noted by the Loading Supervisor during unloading and be sent to Vendor in order to take the appropriate actions to fix them. The received merchandise is unloaded by Loading Employees and is routed from receiving area to dispatch area (for picking/packing if needed). The route of the unloaded merchandise from receiving to dispatch should be tracked (e.g., RFID) by the Loading Supervisor to facilitate the loading process to outbound trucks.

4.3.5.5 Documents

- Shipping Notification

4.3.5.6 Information Systems

- ERP system
- WMS

4.3.5.7 Linked Processes

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4.3.5.8 Supplementary Diagrams

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4.3.6 Execute Value-Added Services for Merchandise Preparation Process (2.2)

Process 2.2: Execute Value-Added Services for Merchandise Preparation

Date of First Version: 17/01/2021

Date of Final Version: 13/02/2021

Aim of the Process: Preparation of merchandise by Department of Logistics according to the needs of each product in order to be ready for store replenishment.

Process Owner: Department of Logistics

Editor: Konstantinos Stergiou

2.2. Execute Value-Added Services for Merchandise Preparation

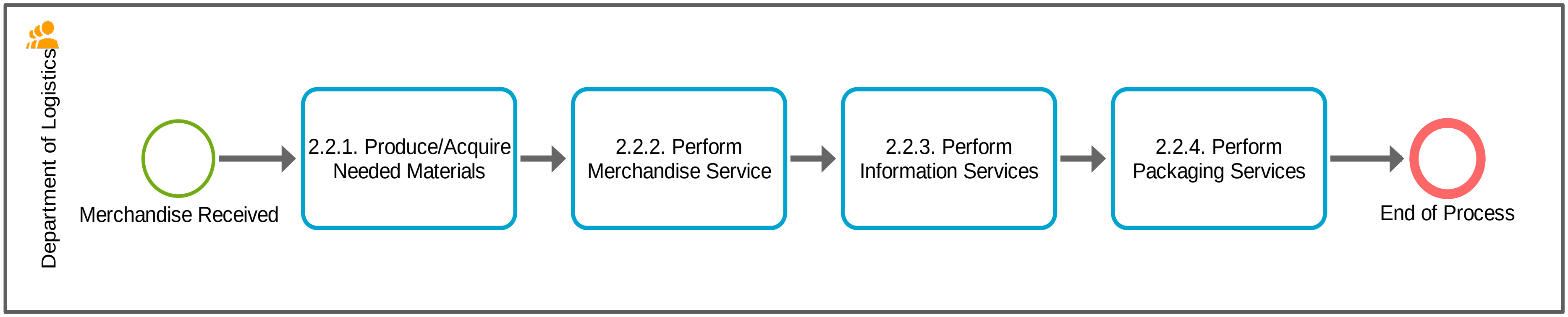

Figure 4.12. Execute Value-Added Services for Merchandise Preparation Process (2.2)

4.3.6.1 Process Prerequisites

- Receipt of Merchandise

4.3.6.2 Process Participants

- Department of Logistics

4.3.6.3 Periodicity of the process

- Depends on the needs of received merchandise

4.3.6.4 Process Description

The process includes four steps that must be executed by the employees of the Department of Logistics. The first step is the production/acquisition of needed materials for merchandise preparation in the form that is appropriate for stores. These materials include the correct merchandise labeling, ticketing, stickering materials and should be available prior to beginning of the product/pallet/case/box transformation. After the production/acquisition of needed materials employees of Logistics perform the necessary merchandise preparation services. Steaming, ticketing, assembling, cleaning, attaching security tags, etc. are examples of merchandise service types of value-added services, if these activities are performed on an out-going basis for the particular product and stores/customer. Then, services that encompass added information are executed, like generation of boxes labels, packaging information, transfer/cross-dock labels with appropriate information, bar code, RFID tags etc. for particular merchandise and stores/customers. The final step is the packaging services which are executed by Logistics employees by selecting appropriate packaging, such as specific carton/box sizes and other unique packaging requirements for merchandise.

4.3.6.5 Documents

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4.3.6.6 Information Systems

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4.3.6.7 Linked Processes

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4.3.6.8 Supplementary Diagrams

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Process 3.1: Picking, Packing and Shipment Preparation

Date of First Version: 24/01/2021

Date of Final Version: 24/06/2021

Aim of the Process: Execution of picking and packing activities of products as well as the preparation of merchandise to be loaded and shipped from DC to stores.

Process Owner: Department of Logistics

Editor: Konstantinos Stergiou

3.1. Picking, Packing and Shipment Preparation

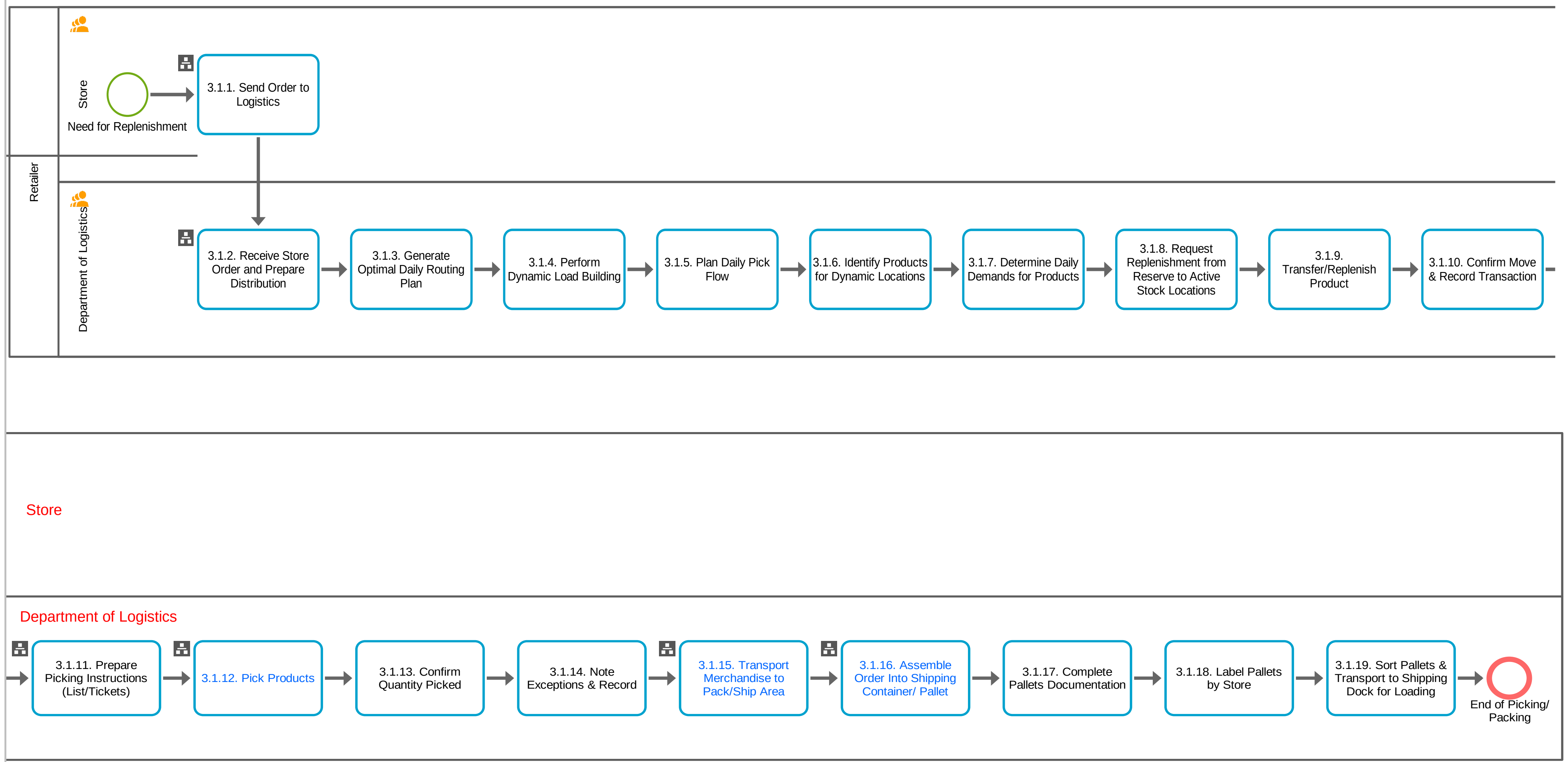


Figure 4.13. Picking, Packing and Shipment Preparation Process (3.1)

4.3.7.1 Process Prerequisites

- Existence of Stores Orders
- Existence of necessary products

4.3.7.2 Process Participants

- Department of Logistics
- Stores

4.3.7.3 Periodicity of the process

- Daily and depends on the needs for products replenishment in stores

4.3.7.4 Process Description

The process starts with the receipt of the order that the Store places in the ERP system based on its needs for replenishment (Process *3.1.1 Order Sending from Stores to Logistics*). The Department of Logistics receives the store and begins with its preparation (Process 3.1.2 *Order Receiving and Distribution Preparation*). The first step of the outbound activity is the generation of the daily truck routing plan, given the profile of the store orders received for fulfillment. Trucks travelling furthest away typically are filled first, followed by the many other customer fulfillment rules decided. After the route plan has been generated, the Department of Logistics performs load building. Load building summarizes store orders by taking into account the size of the truck, stops on the route, and maximum cube of the truck. The result of this step is the creation of an optimal load plan to confirm that the orders expected to ship can actually be fulfilled. Then, based on order urgency, stores requirements and distribution plan, the day's planned pick flow is decided by Department of Logistics. The results of the plan are referenced as a Wave. Waves are logical groups of orders requiring a set number of merchandise picks. DC employees needed to perform efficient picking are reviewed and taken under consideration to adjust pick waves as necessary.

The Department of Logistics should also identify items that will be picked in dynamic (changing) picking locations (promotional items, new items, or items moved infrequently). Then, the Department of Logistics has to review orders making up the day's pick activity and estimate the demand by item (regardless of pick location). After that, a transfer from reserve stock to adequately fill active pick locations is requested, prior to beginning a pick wave. During the day, pick activity will reduce the active pick location inventory which requires periodic replenishment. Maintaining the correct level of inventory in pick locations can be achieved through adequate planning and continuous analysis of product fluctuations. The goal is to reduce product movement within the facility and guarantee 100% availability of merchandise from the expected pick location. The transfer of items is followed by the confirmation that the move was completed (in WMS). There are various methods and innovative practices supporting this activity. Methods range from immediate case label/location scanning through the usage of RF or RFID to manually recording on paper and later entering into an inventory locator system. Subsequently, the Department of Logistics is responsible for preparing through WMS the appropriate documentation to support picking, packing and loading the orders. Documentation can be in the form of manual paper pick lists, pick tickets and case labels; or it can be totally non-paper based, where RF or RFID technology is used to instruct the picker of the location to pick from, the product quantity to pick, and where to take the product. The user simply confirms the successful completion after each step in movement. Then, the pickers of the Department of Logistics physically pick products from pick location. The confirmation that the quantity ordered is the quantity picked must be occurred, too. The act of picking must also release actual recorded inventory within the WMS. The pickers of Department of Logistics should note and record exceptions, which can include incorrect pick location, pick location empty, merchandise damaged or not enough product in location to pick, as well. When exceptions occur, problems must be adequately recorded and instructions for alternative methods of retrieving products followed.

After the completion of picking, the merchandise is transported to packing/shipping area where it will be placed in pallets and will be prepared for shipping, along with the preparation of Final Distribution Plan (Process *3.1.16 Final Distribution Plan Preparation*). Advanced material handling like conveyors can accelerate this activity. Then, the merchandise is packed by the employees of the Department of Logistics, according to store orders, into appropriate shipping containers/ pallets. Merchandise may be fluid, loaded into the trailer for further breakdown by a consolidator. The next step is the completion of pallets documentation including details about the products packed within them. This documentation can be in the form of an externally applied contents label or manually printed packing slip inserted prior to taping. Then, store (destination) labels are generated and attached to pallets/carton prior to shipping by the Department of Logistics and the pallets/cartons/containers are transported to appropriate shipping dock based on the loading plan. This step can be relatively manual, or highly automated. If scannable shipping labels are used, quick movement of labeled cartons to the shipping doors can be accomplished using advanced sorting equipment supported by high-speed label scanners. The completion of this process leads to Process *3.1.19 Load Trucks*.

4.3.7.5 Documents

- Picking Documentation
- Pallets Documentation

4.3.7.6 Information Systems

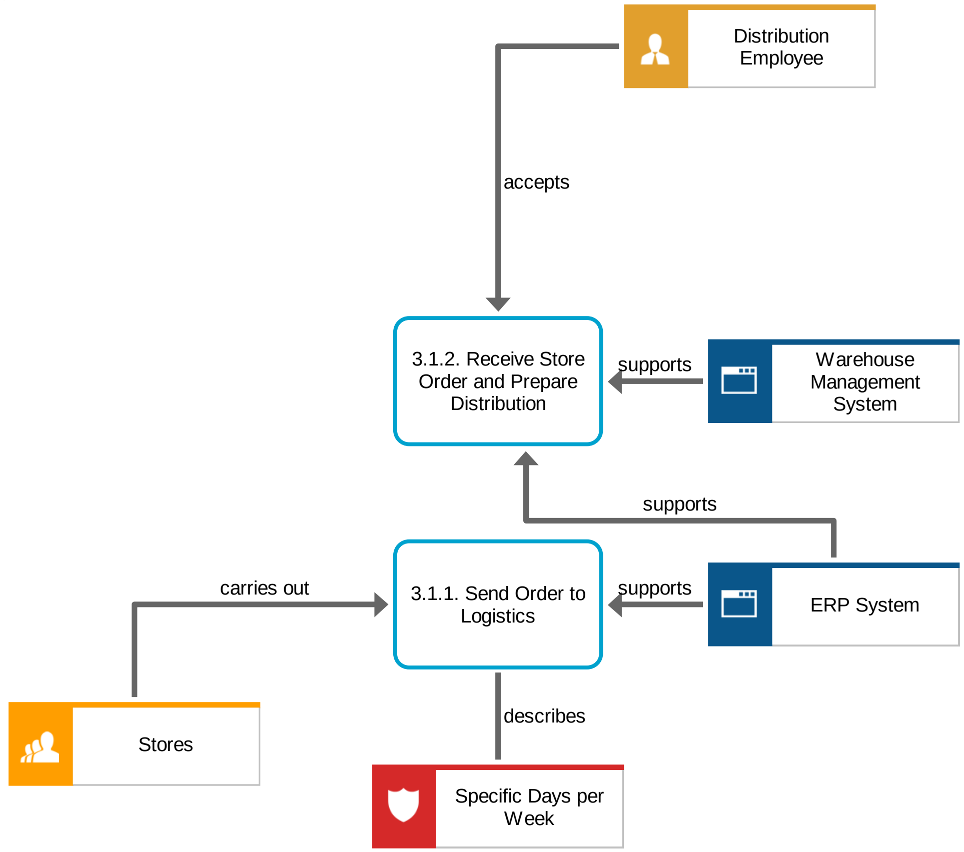
- ERP system
- WMS

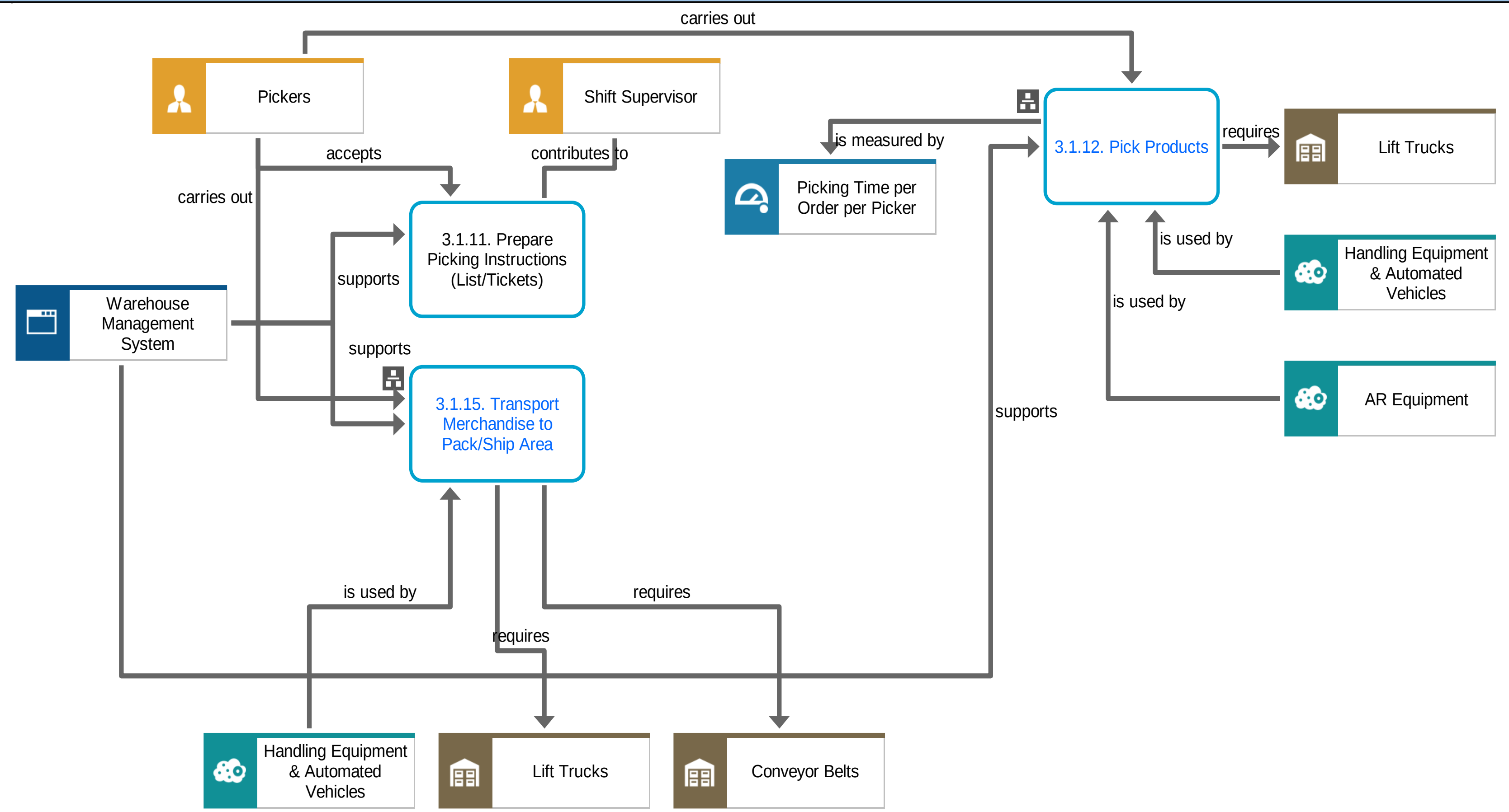
4.3.7.7 Linked Processes

- 3.1.1 Order Sending from Stores to Logistics
- 3.1.2 Order Receiving and Distribution Preparation
- 3.1.16 Final Distribution Plan Preparation
- 3.1.19 Load Trucks

4.3.7.8 Supplementary Diagrams

Table 4.7. Supplementary Diagrams for Picking, Packing and Shipment Preparation Process (3.1)

Activity	Function Allocation Diagram
3.1.1. Send Order to Logistics *3.1.2. Receive Store Order and Prepare Distribution*	

Activity	Function Allocation Diagram
3.1.11. Prepare Picking Instructions (List/Tickets) 3.1.12. Pick Products 3.1.15. Transport Merchandise to Pack/Ship Area	

Process 3.1.1: Order Sending from Stores to Logistics

Date of First Version: 26/01/2021

Date of Final Version: 30/04/2021

Aim of the Process: Preparation and decision by the Store Manager of sending an order to DC.

Process Owner: Store Manager

Editor: Konstantinos Stergiou

3.1.1 Order Sending from Store to Logistics

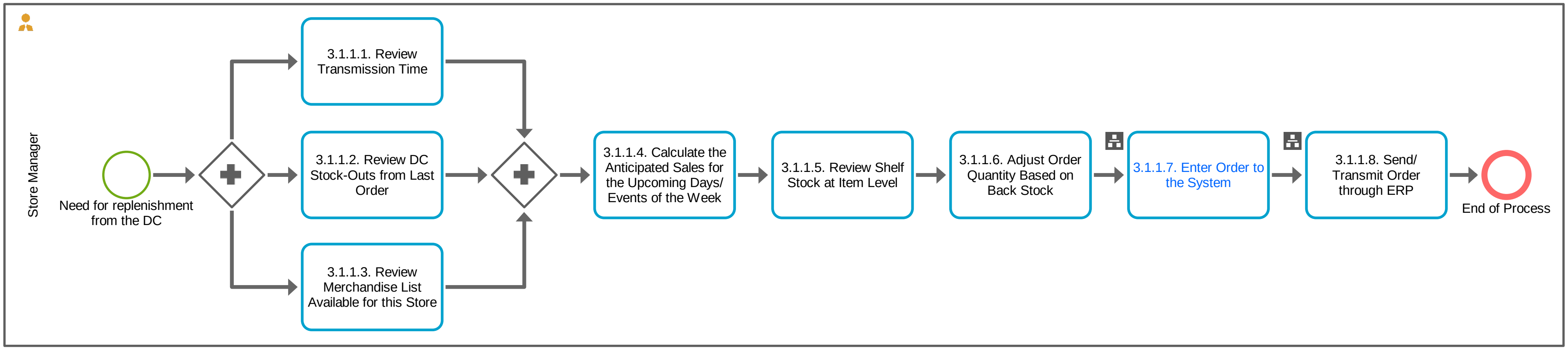


Figure 4.14. Order Sending from Stores to Logistics Process (3.1.1)

4.3.8.1 Process Prerequisites

- Need for merchandise replenishment in store

4.3.8.2 Process Participants

- Store Manager

4.3.8.3 Periodicity of the process

- Depends on the needs for products replenishment in store

4.3.8.4 Process Description

The process starts with 3 actions by the Store Manager. The review of transmission time to understand when order transmissions must be started and completed in order to ensure delivery, the review of DC stock-outs from the last order(s), and the review of merchandise list (SKUs) that is available for this specific store. Then, the Store Manager, with the help of Forecasting System or algorithm, should calculate the customer demand for events or high traffic days by taking under consideration merchandising planning, sales trends and sales projections. After that, the Store Manager must check shelf stock at item level. This activity can be occurred physically with a walk in shop floor or using advanced technologies for the tracking of shelf stock (IoT sensors sending information about shelf stock to ERP). In addition, the Store Manager should review back-stock physically or through the ERP system and adjust the quantity of order. After collecting all the necessary data, the Store Manager enters the order to the system and sends it to the Logistics through ERP system during the correct order window.

4.3.8.5 Documents

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4.3.8.6 Information Systems

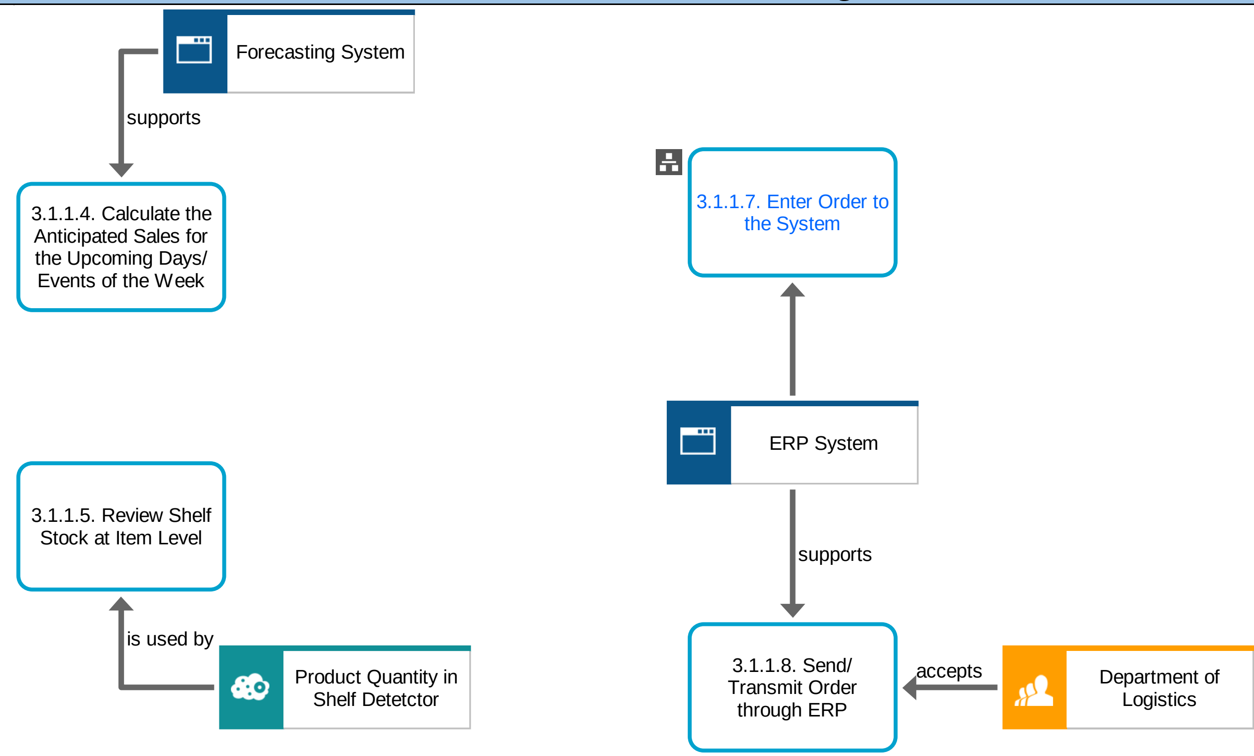
- ERP system
- Forecasting system

4.3.8.7 Linked Processes

-

4.3.8.8 Supplementary Diagrams

Table 4.8. Supplementary Diagrams for Order Sending from Stores to Logistics Process (3.1.1)

Activity	Function Allocation Diagram
3.1.1.4. Calculate the Anticipated Sales for the Upcoming Days/ Events of the Week 3.1.1.5. Review Shelf Stock at Item Level 3.1.1.7. Enter Order to the System 3.1.1.8. Send/ Transmit Order through ERP	

Process 3.1.2: Order Receiving and Distribution Preparation

Date of First Version: 27/01/2021

Date of Final Version: 02/05/2021

Aim of the Process: Execution of all the activities that precede the preparation of products to be shipped and include the first planning of the distribution process based on incoming orders from stores.

Process Owner: Planner

Editor: Konstantinos Stergiou

3.1.2 Order Receiving and Distribution Preparation

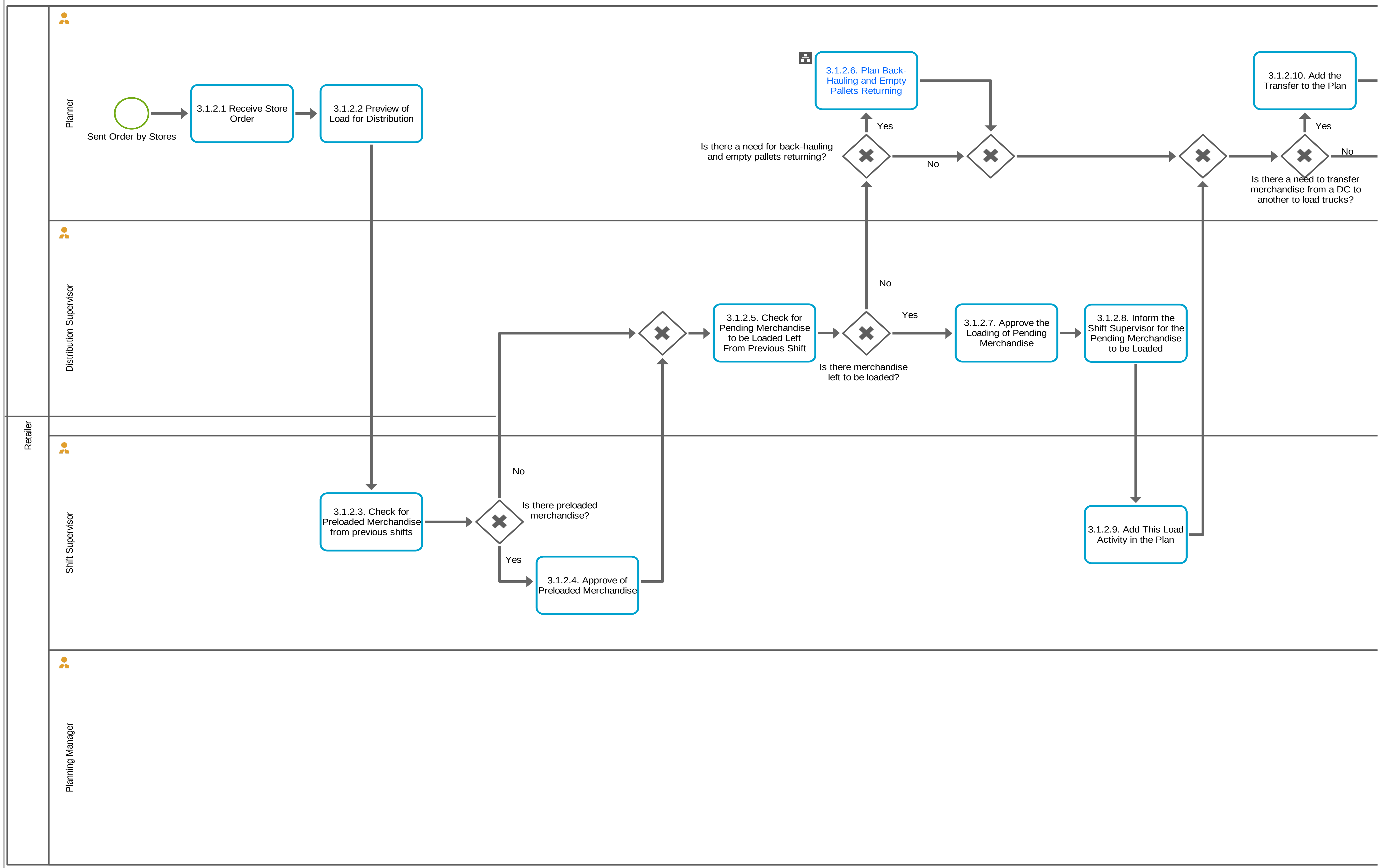
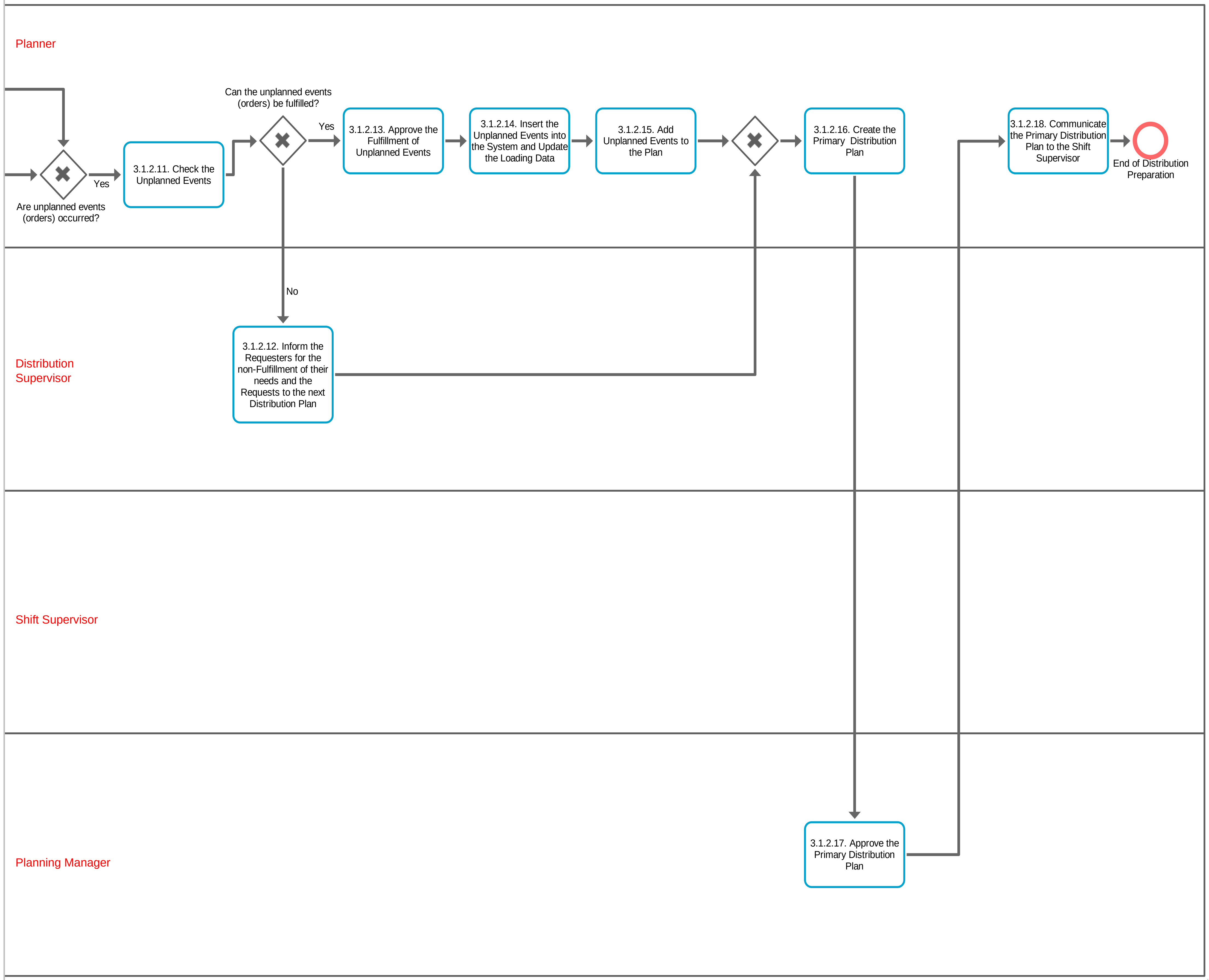


Figure 4.15. Order Receiving and Distribution Preparation Process (3.1.2)


Planner
Distribution Supervisor
Shift Supervisor
Planning Manager
Are unplanned events (orders) occurred?
Yes
3.1.2.11. Check the Unplanned Events
Can the unplanned events (orders) be fulfilled?
Yes
No
3.1.2.12. Inform the Requesters for the non-Fulfillment of their needs and the Requests to the next Distribution Plan
3.1.2.13. Approve the Fulfillment of Unplanned Events
3.1.2.14. Insert the Unplanned Events into the System and Update the Loading Data
3.1.2.15. Add Unplanned Events to the Plan
3.1.2.16. Create the Primary Distribution Plan
3.1.2.17. Approve the Primary Distribution Plan
3.1.2.18. Communicate the Primary Distribution Plan to the Shift Supervisor
End of Distribution Preparation

4.3.9.1 Process Prerequisites

- Existence of Store Orders

4.3.9.2 Process Participants

- Planner
- Distribution Supervisor
- Shift Supervisor
- Planning Manager

4.3.9.3 Periodicity of the process

- Daily, depending on stores' orders

4.3.9.4 Process Description

The process starts with the review of the orders, placed in ERP system by the Stores, by the Planner. The orders are automatically transmitted from the ERP to the WMS and DMS (Distribution Management System) in order to be translated in in the language of loading and distribution activities. Then, the planner should preview the load needed for distribution to stores from the DMS according to stores orders. The Shift Supervisor, at the same time, check whether there is preloaded merchandise from previous shifts (through WMS) and continues with the approval of preloaded merchandise if exists. The preloaded merchandise is a result of shift changing and concerns the products of orders that have been loaded incompletely to this point. Another result of shift changing is the pending merchandise that should be loaded left from previous shifts. The Distribution Supervisor checks (through DMS) if there is merchandise left to be loaded. If yes, he/she have to give his/her approval for loading of pending merchandise and informs the Shift Supervisor to add the pending merchandise to be loaded in the plan. The Shift Supervisor, subsequently, adds the loading of pending merchandise to the loading plan. If there is no pending merchandise to be loaded from previous shift, the Planner checks if there is a need for back-hauling and empty pallets returning (Process *3.1.2.6 Back-Hauling Planning*) from stores and add them to primary distribution plan. If there is no need for back-hauling and empty pallets returning, the flow continues with the Planner checking if merchandise transfer from a DC to another DC is needed. If such a transfer is needed, then it is added to the plan. Otherwise, the planner checks whether unplanned events (e.g., unplanned or wrong orders, trucks malfunctions) have occurred. If there are unplanned events, the Planner checks whether the unplanned events can be fulfilled. If they cannot be fulfilled, the Planner informs the Distribution Supervisor for giving replies to requesters of unplanned events that their requests will be added to next distribution plan. If the unplanned events can be fulfilled, the Planner approves them and informs the Distribution Supervisor and the Shift Supervisor for their approval. After that, the Planner inserts the unplanned events in the DMS and uploads the loading plan accordingly.

The final step is the configuration of the Primary Distribution Plan by the Planner in the DMS. The Planner collects all the necessary data and information for the creation of the plan including loads to be delivered in each store, the preloaded merchandise, the merchandise pending to be loaded, the flow of the picking process from the WMS (in this specific day), unplanned events, and back-hauling needs. All these data and information can be found systemically or non-systemically. The Primary Distribution Plan should, then, be approved by the Panning Manager (if there is the capability through DMS). Once the Primary Distribution Planned is approved, the Planner communicates it to the Shift Supervisor.

4.3.9.5 Documents

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4.3.9.6 Information Systems

- ERP system
- WMS
- DMS

4.3.9.7 Linked Processes

- 3.1.2.6 Back-Hauling Planning

4.3.9.8 Supplementary Diagrams

-

Process 3.1.2.6: Back-Hauling Planning

Date of First Version: 30/01/2021

Date of Final Version: 06/05/2021

Aim of the Process: Planning of back-hauling and empty pallets transfer to DC and their integration with the Distribution Plan.

Process Owner: Planning Manager

Editor: Konstantinos Stergiou

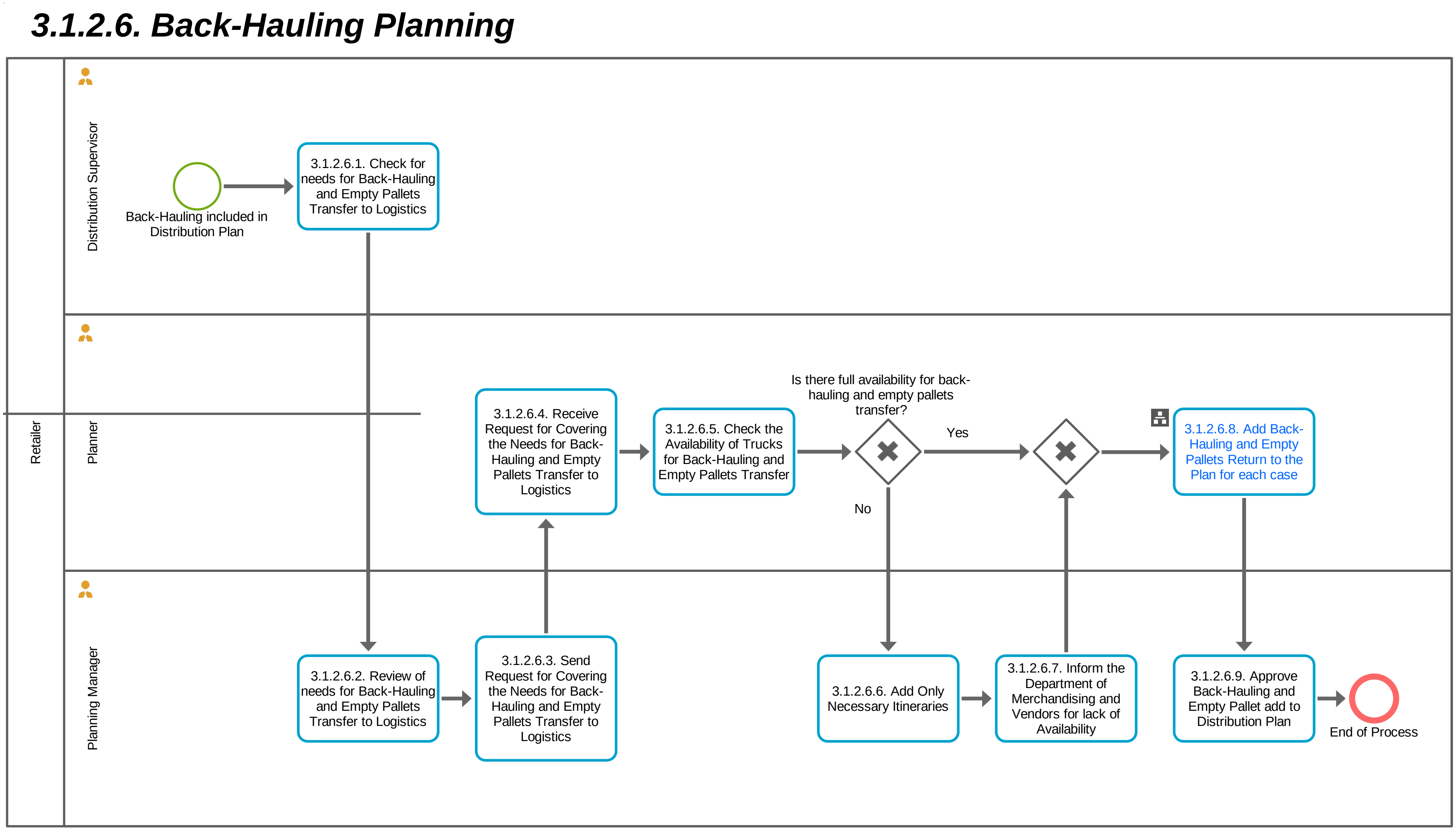


Figure 4.16. Back-Hauling Planning Process (3.1.2.6)

4.3.10.1 Process Prerequisites

- Existence of back-hauling contracts

4.3.10.2 Process Participants

- Planning Manager
- Planner
- Distribution Supervisor

4.3.10.3 Periodicity of the process

- Process execution depends on back-hauling contracts that can be included on the daily distribution plan and the needs of empty pallets returning to DC

4.3.10.4 Process Description

The first step of the process is the checking of the needs for back-hauling and empty pallet return to Logistics by the Distribution Supervisor. Back-hauling occurs based on the contracts with Vendors. The fulfilment of specifications set by Logistics and the promotion of products are the two main factors in deciding back-hauling with Vendor. The Planning Manager is informed by Distribution Supervisor about needs for back-hauling and empty pallets (boxes, cages etc.) returning to Logistics and reviews them. If he/she approves these needs, he/he sends a request to the Planner to include in the plan back-hauling from specific Vendors and transferring of empty pallets from stores to logistics, along with possible instructions for their execution.

The Planner receives the request and instructions from the Planning Manager and checks the availability of the trucks which are programmed to perform a two-way route (own or third-party) in order to execute back-hauling and empty pallets returning. If there is no availability, the Planning Manager adds only necessary itineraries to be carried out by trucks giving the appropriate priority to the directions have been given by Department of Merchandising about which products to serve first. Then, the Planning Manager informs the Department of Merchandising and Vendors for lack of availability of trucks for back-hauling. Back-hauling and empty pallets returning are subsequently added to the Distribution Plan through DMS by the Planner according to the direction of the Planning Manager and the availability of trucks and finally, the Planning Manager checks and approves the Distribution Plan including back-hauling and empty pallets return.

4.3.10.5 Documents

-

4.3.10.6 Information Systems

- DMS

4.3.10.7 Linked Processes

-

4.3.10.8 Supplementary Diagrams

-

Process 3.1.16: Prepare Final Distribution Plan

Date of First Version: 30/01/2021

Date of Final Version: 11/05/2021

Aim of the Process: Configuration of the Final Distribution Plan after the primary distribution preparation has been finished.

Process Owner: Planner

Editor: Konstantinos Stergiou

3.1.16 Prepare Final Distribution Plan

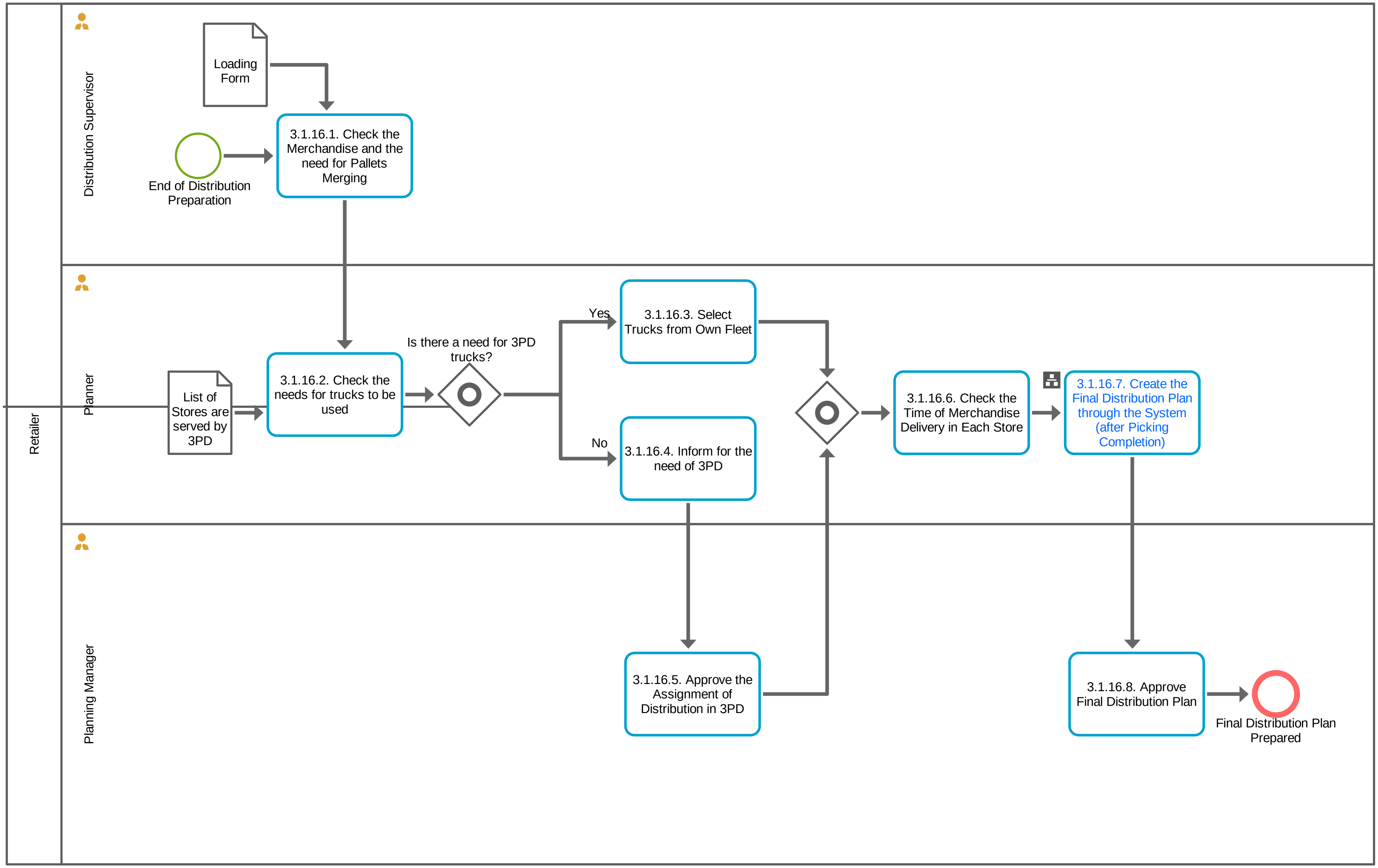


Figure 4.17. Prepare Final Distribution Plan (3.1.16)

4.3.11.1 Process Prerequisites

- Completion of Loading preparation (final stage of picking)

4.3.11.2 Process Participants

- Planning Manager
- Planner
- Loading Supervisor

4.3.11.3 Periodicity of the process

- Daily depending on the orders prepared for delivery to stores

4.3.11.4 Process Description

The process starts when the distribution preparation has been completed (Process *3.1.2 Order Receiving and Distribution Preparation*) and the picking is on the last stage of the checking of merchandise and the need for pallets merging (or diverging) by the Loading Supervisor in order to fully load trucks. This step is occurred with the help of Loading Form existing in WMS and DMS which is updated with pallets merging (or diverging). The Loading Form also records the loading lanes from which the orders will be loaded to trucks.

After this step, the Planner checks the needs for trucks to be used for delivery to stores. The size of the truck, the area of delivery and its ability to deliver each kind of products with special characteristics (e.g., sensitive food products) is taken under consideration. Then, the Planner decides whether is a need for the usage of 3PD and which 3PD can be used according to the List of Stores that 3PD can serve existing in DMS. If there is such a need for the covering of deliveries, the Planer informs the Planning Manager in order to take approval and informs (3PD) for the trucks needed based on the signed contract. The Planner also selects trucks from own fleet to execute itineraries based on the factors that were previously described. Subsequently, the Planner should check the time margin that is set for each store in order to schedule the delivery, taking under consideration particular details of each store (e.g., days of being closed, area traffic, etc.), too.

The final step of the process is the creation of the Final Distribution Plan by the Planner (after picking completion) through DMS. The plan is configured according to the availability of drivers and based on the factors described for each store through the DMS. The Planning Manager, then, checks and approves the Final Distribution Plan with should be communicated to 3PD if needed.

4.3.11.5 Documents

- Loading Form
- List of Stores served by 3PD

4.3.11.6 Information Systems

- DMS
- WMS

4.3.11.7 Linked Processes

- 3.1.2 Order Receiving and Distribution Preparation

4.3.11.8 Supplementary Diagrams

-

Process 3.1.19: Load trucks

Date of First Version: 02/02/2021

Date of Final Version: 01/06/2021

Aim of the Process: Execution of all the necessary activities by Logistics in order to load trucks with merchandise that will be delivered to stores.

Process Owner: Shift Supervisor

Editor: Konstantinos Stergiou

3.1.19 Load Trucks

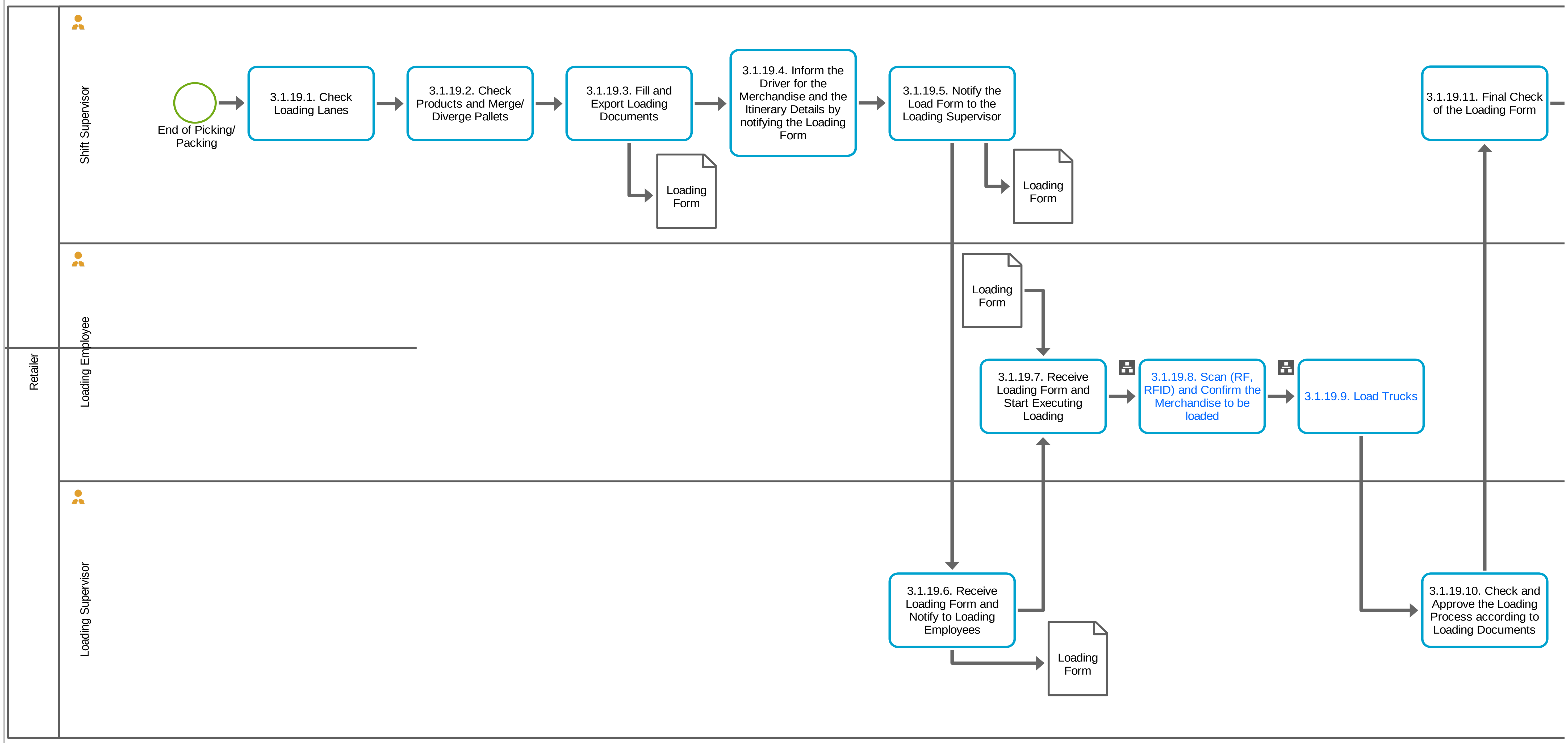
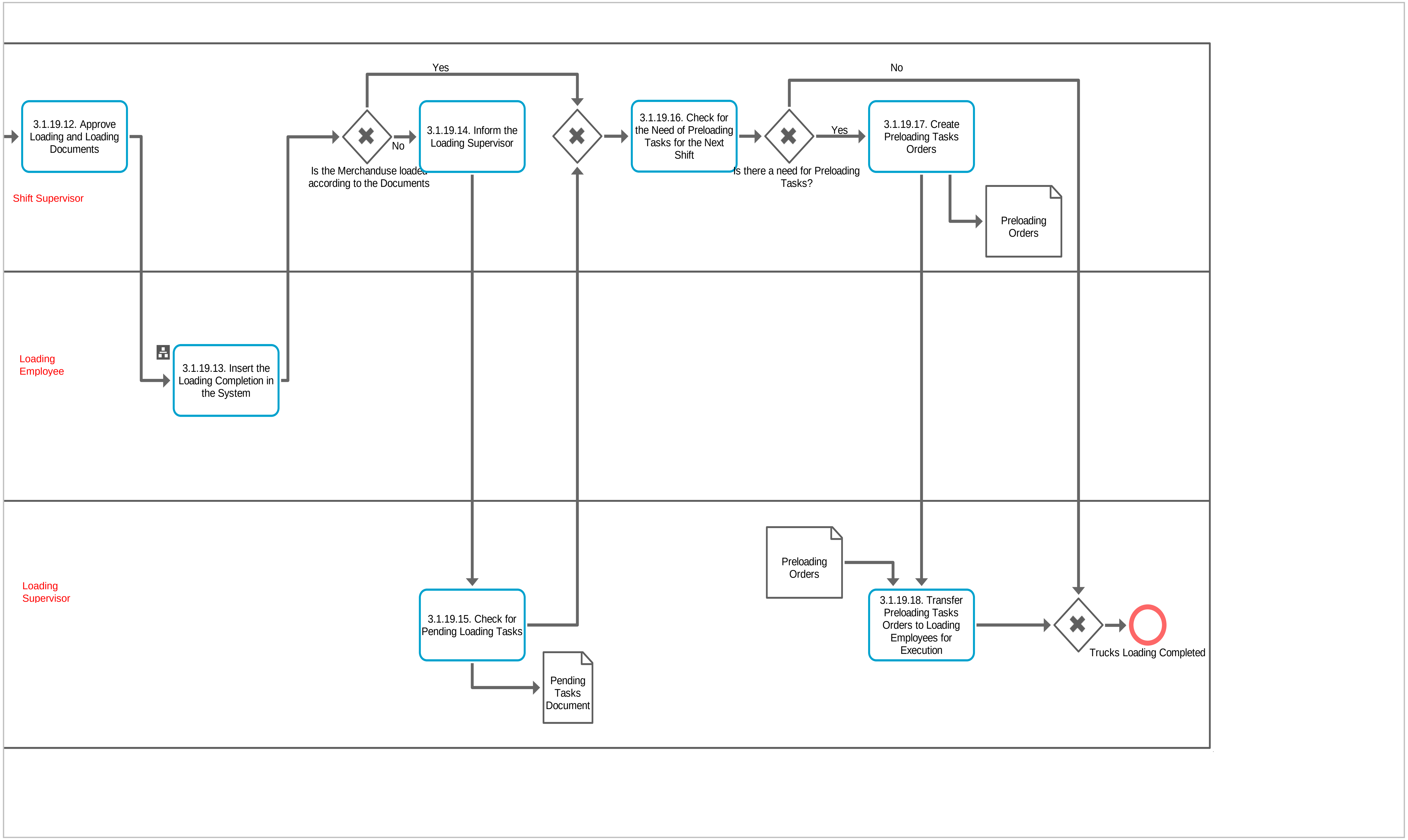


Figure 4.18. Load trucks Process (3.1.19)


Shift Supervisor
Loading Employee
Loading Supervisor
3.1.19.12. Approve Loading and Loading Documents
3.1.19.13. Insert the Loading Completion in the System
Is the Merchandise loaded according to the Documents
Yes
No
3.1.19.14. Inform the Loading Supervisor
3.1.19.15. Check for Pending Loading Tasks
Pending Tasks Document
3.1.19.16. Check for the Need of Preloading Tasks for the Next Shift
Is there a need for Preloading Tasks?
Yes
No
3.1.19.17. Create Preloading Tasks Orders
Preloading Orders
Preloading Orders
3.1.19.18. Transfer Preloading Tasks Orders to Loading Employees for Execution
Trucks Loading Completed

4.3.12.1 Process Prerequisites

- Picking and Packing Completion

4.3.12.2 Process Participants

- Shift Supervisor
- Loading Supervisor
- Loading Employee

4.3.12.3 Periodicity of the process

- Daily, depending on the deliveries that will be executed from Logistics to Stores

4.3.12.4 Process Description

After the picking and packing completion the process of loading follows. The first step of the loading process is the checking of loading lanes in which the merchandise has been transferred after picking and packing completion by the Shift Supervisor (through WMS or DMS). The Shift Supervisor also decides about merging (or diverging) of pallets (with the help of DMS). Then, the Shift Supervisor fills and exports the Loading Form through the DMS which includes all the necessary information such as the loading order number, the destination of delivery, the DC, the dock from which the loading will be executed, the truck used, the type of merchandise, the number of pallets/boxes, the time of departure from DC. After that, the Shift Supervisor notifies the truck driver to move to the dock indicated in the Loading Form and notifies the Loading Form to the Loading Supervisor (through DMS or physically).

The Loading Supervisor receives the Loading Form and notifies Loading Employees for the starting of the loading process. The first step of loading is the scanning of products tags (barcodes with RF scanner or RFID tags with RFID scanner) in order to confirm the merchandise to be loaded from a specific lane to a specific truck. Then, the pallet/boxes are loaded by Loading Employees to trucks (or by autonomous vehicles). The Loading Supervisor checks the loading process based on the Loading Form and approves it. Then, the Shift Supervisor carries out a final check of the Lording Form and also checks the loading correctness and approves it.

The Loading Employee, then, inserts the loading completion in the WMS using the RF (or RFID) scanner in order to be used later for the print of the Delivery Document (Processes *4.1 Distribute Merchandise*, *4.1.4a Delivery to Stores Execution*). If there is merchandise that was not loaded according to the Loading Form, then the Shift Supervisor informs the Loading Supervisor for pending merchandise to be loaded. The Loading Supervisor checks the pending merchandise and adds it to Pending Task Document in WMS and DMS.

The next step is the checking by the Shift Supervisor of the need for preloading merchandise for the next shift. If there is such a need and there is the availability to be covered, the Shift Supervisor creates a Preloading Order through the WMS and communicates it to the Loading Supervisor. The Loading Supervisor is, subsequently, in charge of the execution of the Preloading Order by the Loading Employees.

4.3.12.5 Documents

- Loading Form
- Pending Tasks Document
- Preloading Order

4.3.12.6 Information Systems

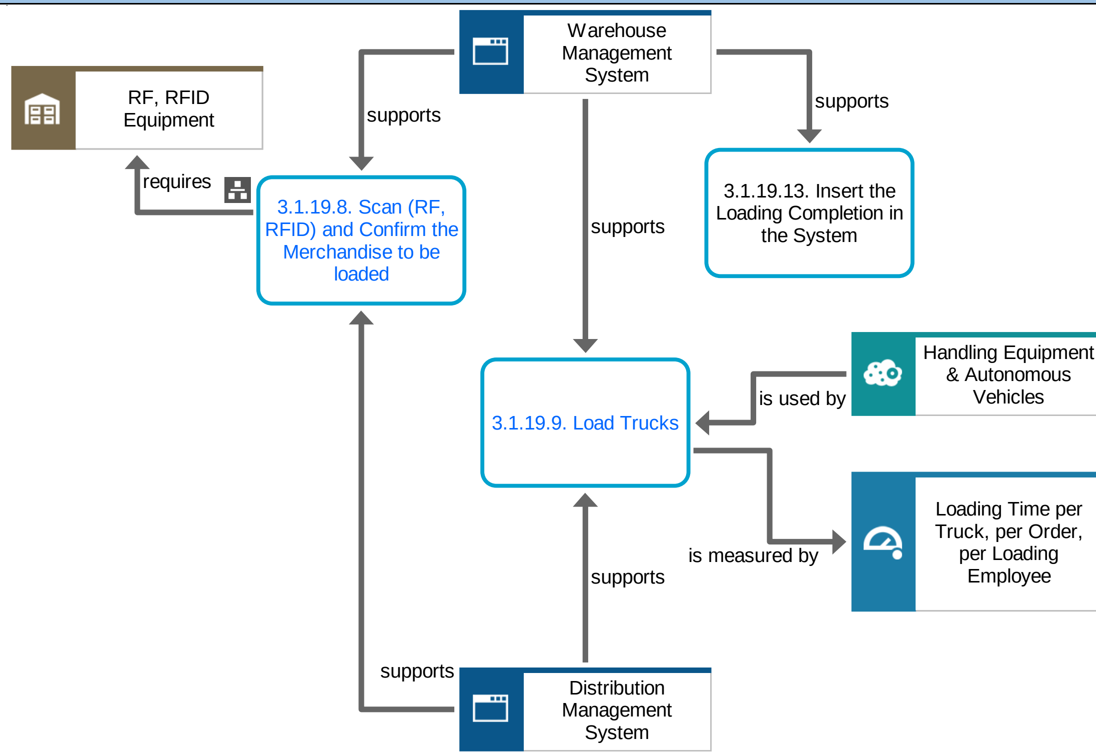
- WMS
- DMS

4.3.12.7 Linked Processes

- 4.1 Distribute Merchandise
- 4.1.4a Delivery to Stores Execution

4.3.12.8 Supplementary Diagrams

Table 4.9. Supplementary Diagrams for Load trucks Process (3.1.19)

Activity	Function Allocation Diagram
3.1.19.8. Scan (RF, RFID) and Confirm the Merchandise to be loaded 3.1.19.9. Load Trucks 3.1.19.13. Insert the Loading Completion in the System	

Process 4.1: Distribute Merchandise

Date of First Version: 03/02/2021

Date of Final Version: 17/04/2021

Aim of the Process: Determination of the right order quantity along with the preparation and sending of Purchase Orders (PO) to Vendor.

Process Owner: Department of Logistics

Editor: Konstantinos Stergiou

4.1 Distribute Merchandise

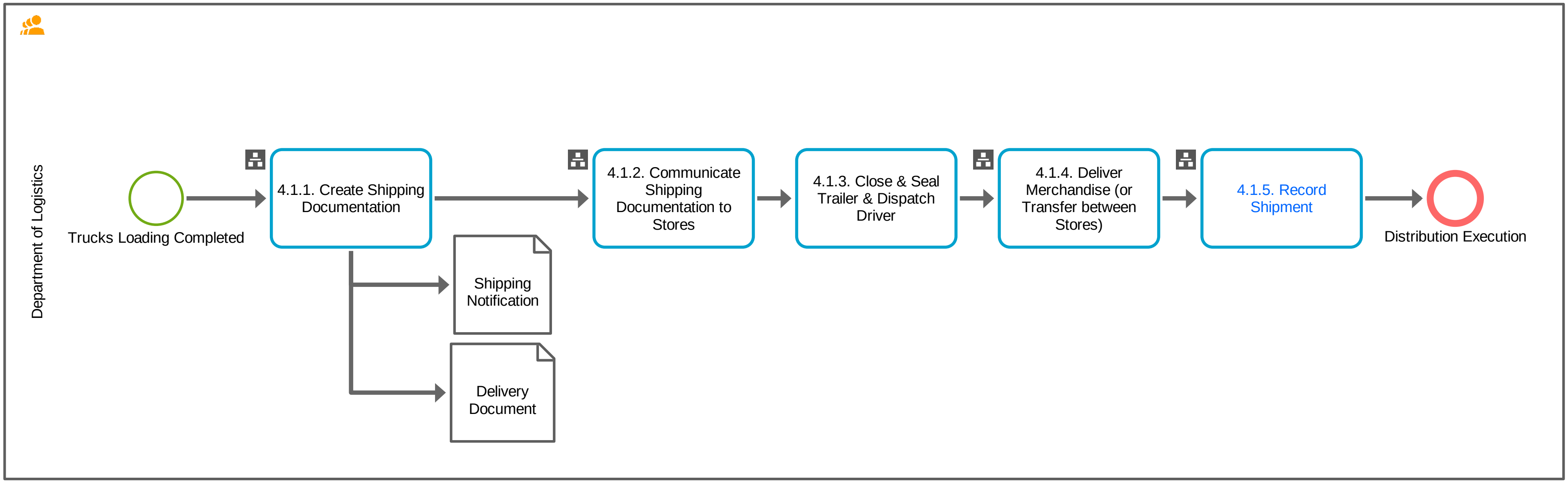


Figure 4.19. Distribute Merchandise Process (4.1)

4.3.13.1 <u>Process Prerequisites</u>

- Picking, Packing and Loading Completion

4.3.13.2 <u>Process Participants</u>

- Department of Logistics

4.3.13.3 <u>Periodicity of the process</u>

- Daily, depending on the deliveries that area executed from Logistics to Stores

4.3.13.4 <u>Process Description</u>

After the Picking, Packing and Loading Completion (Processes *3.1 Picking, Packing and Shipment Preparation, 3.1.19 Load Trucks)* the Department of Logistics prepares the shipment documentation including Shipping Notification and Delivery Document. These documents are communicated, through the ERP system, to Stores in order to know the exact merchandise that it will be received. Then, the trailer is closed and sealed, and the driver is released. The merchandise is shipped to stores (or customers) according to the schedule and the shipment is recorder, through the DMS, by the Department of Logistics in order to exactly know the time of arrival in stores (or customers).

This process is further analysed in Process *4.1.4a Delivery to Stores Execution* and conventionally includes Process 4.1.4b *Transfer of Merchandise among Stores.*

4.3.13.5 <u>Documents</u>

- Shipping Notification
- Delivery Document

4.3.13.6 <u>Information Systems</u>

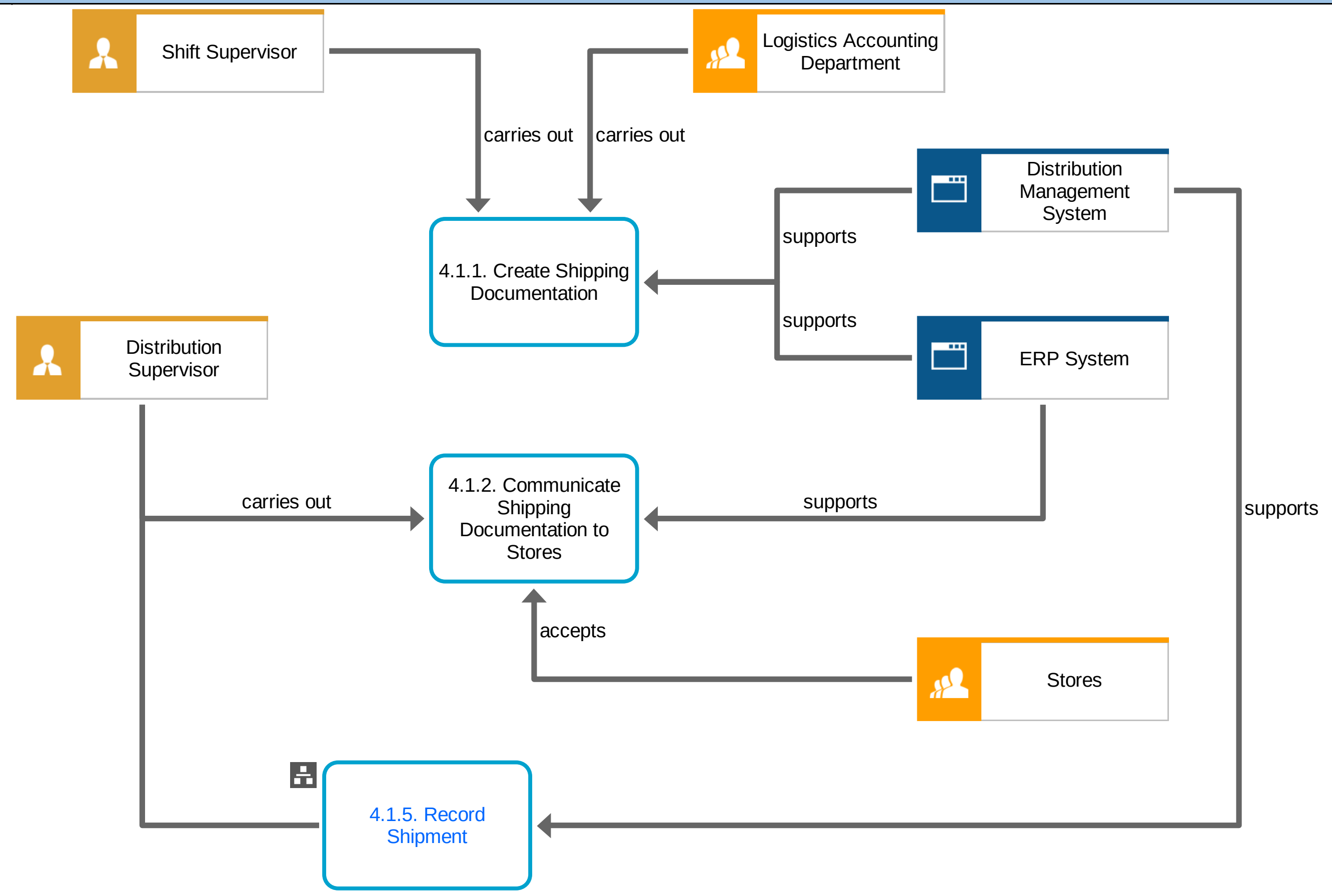
- ERP system
- DMS

4.3.13.7 <u>Linked Processes</u>

- 3.1 Picking, Packing and Shipment Preparation
- 3.1.19 Load Trucks
- 4.1.4a Delivery to Stores Execution
- 4.1.4b Transfer of Merchandise among Stores

4.3.13.8 Supplementary Diagrams

Table 4.10. Supplementary Diagrams for Distribute Merchandise Process (4.1)

Activity	Function Allocation Diagram
4.1.1. Create Shipping Documentation 4.1.2. Communicate Shipping Documentation to Stores 4.1.5. Record Shipment	

Process 4.1.4a: Delivery to Stores Execution

Date of First Version: 03/02/2021

Date of Final Version: 22/04/2021

Aim of the Process: Delivery of merchandise from the DC to Stores.

Process Owner: Driver

Editor: Konstantinos Stergiou

4.1.4a Delivery to Stores Execution

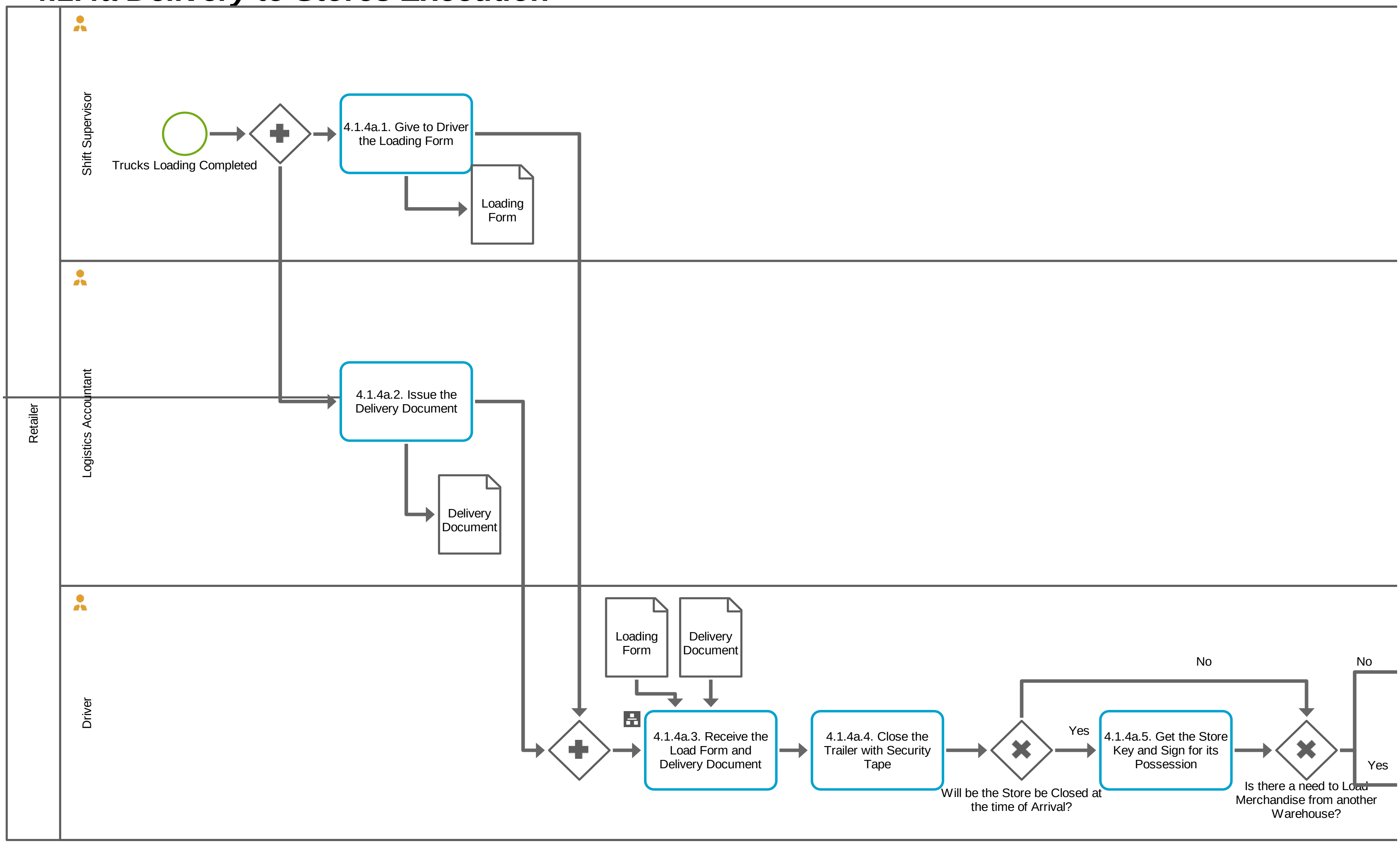
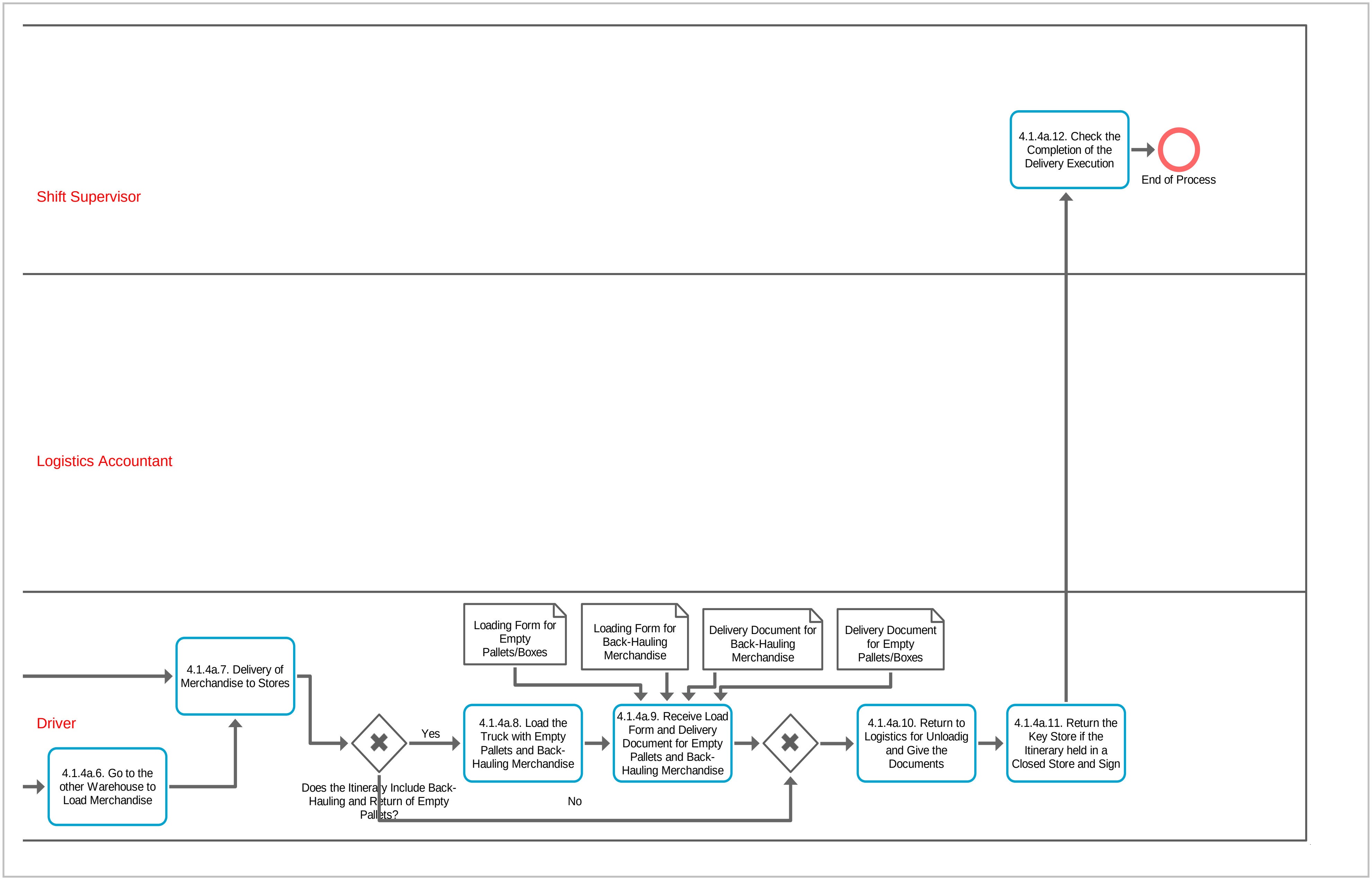


Figure 4.20. Delivery to Stores Execution Process (4.1.4a)



Shift Supervisor
Logistics Accountant
Driver
4.1.4a.12. Check the Completion of the Delivery Execution
End of Process
4.1.4a.7. Delivery of Merchandise to Stores
4.1.4a.6. Go to the other Warehouse to Load Merchandise
Does the Itinerary Include Back-Hauling and Return of Empty Pallets?
Yes
No
Loading Form for Empty Pallets/Boxes
Loading Form for Back-Hauling Merchandise
Delivery Document for Back-Hauling Merchandise
Delivery Document for Empty Pallets/Boxes
4.1.4a.8. Load the Truck with Empty Pallets and Back-Hauling Merchandise
4.1.4a.9. Receive Load Form and Delivery Document for Empty Pallets and Back-Hauling Merchandise
4.1.4a.10. Return to Logistics for Unloadig and Give the Documents
4.1.4a.11. Return the Key Store if the Itinerary held in a Closed Store and Sign

4.3.14.1 Process Prerequisites

- Completion of Trucks Loading

4.3.14.2 Process Participants

- Driver
- Shift Supervisor
- Logistics Accountant

4.3.14.3 Periodicity of the process

- Daily, depending on the number of the orders that should be delivered to stores

4.3.14.4 Process Description

This process is lower level and more detailed depiction of the general distribution process (Process *4.1 Distribute Merchandise*) and focuses on the activities of the preparation and execution of delivery to stores. It covers the time period of the departing of truck from DC until the returning of it in the DC.

In the beginning of the process the Shift Supervisor gives to the Driver the Loading Form (after loading completion, Process *3.1.19 Load Trucks*), including all the necessary information for the execution of the delivery. Then, the Logistics Accounting Department prints the Delivery Document through ERP, with the information transferred by the WMS about the load, in order to give the ability to the Store to get informed via ERP system for the delivery details. The Driver receives the Loading Form and the Delivery Document by Shift Supervisor and Logistics Accounting Department, respectively, (these documents can be transferred electronically in a tablet that the driver carries with him/her) and closes the Trailer with a security tape given to him by the Shift Supervisor. After that, the Driver is informed whether the Store will be closed during the delivery of the merchandise. If the Sore will be closed, the Driver takes the key in order to open the Store and leave the merchandise inside, and signs for possessing the key. In the case that there is a need for loading merchandise from another warehouse, except the one from which the truck was departed, the Driver is informed and should go to the other warehouse and load the extra merchandise.

Subsequently, the Driver delivers the Merchandise to Stores and after the receipt of merchandise by the Store, the Store Manager signs the Delivery Document (the process of receipt merchandise by Stores is described in Process *5.1 (Stores) Receive Merchandise from Logistics*). If the itinerary includes back-hauling or empty pallets/boxes returning the Driver is in charge of loading the back-haling merchandise and the empty pallets/boxes from the Vendor warehouse and the Store, respectively. The Driver also receive from the Vendor, if the returning itinerary includes back-hauling, a Loading Form and a Delivery Document for Back-Hauling Merchandise and from the Store Manager, if the returning itinerary includes empty pallets/boxes, a Load From and a Delivery Document of Empty Pallets/Boxes (both of which can be transferred electronically through ERP to Drivers' tablet).

Finally, the Driver returns to Logistics for the unloading of truck's load ang gives to the Shift Supervisor the documents of delivery and return. The Driver also returns the key (if the delivery was occurred in a closed store) and signs for its returning. The Shift Supervisor, then, checks the Documents in order to confirm that the delivery was executed correctly.

4.3.14.5 Documents

- Loading Form

- Delivery Document
- Loading Form for Empty Pallets/Boxes
- Loading Form for Back-Hauling Merchandise
- Delivery Document for Empty Pallets/Boxes
- Delivery Document for Back-Hauling Merchandise

4.3.14.6 Information Systems

- ERP system
- WMS

4.3.14.7 Linked Processes

- 4.1 Distribute Merchandise
- 5.1 (Stores) Receive Merchandise from Logistics
- 3.1.19 Load Trucks

4.3.14.8 Supplementary Diagrams

-

Process 4.1.4b: Transfer of Merchandise among Stores

Date of First Version:03/02/2021

Date of Final Version: 22/04/2021

Aim of the Process: Planning of the imperative need for transferring merchandise from a store to another.

Process Owner: Planning Manager

Editor: Konstantinos Stergiou

4.1.4b. Transfer of Merchandise among Stores

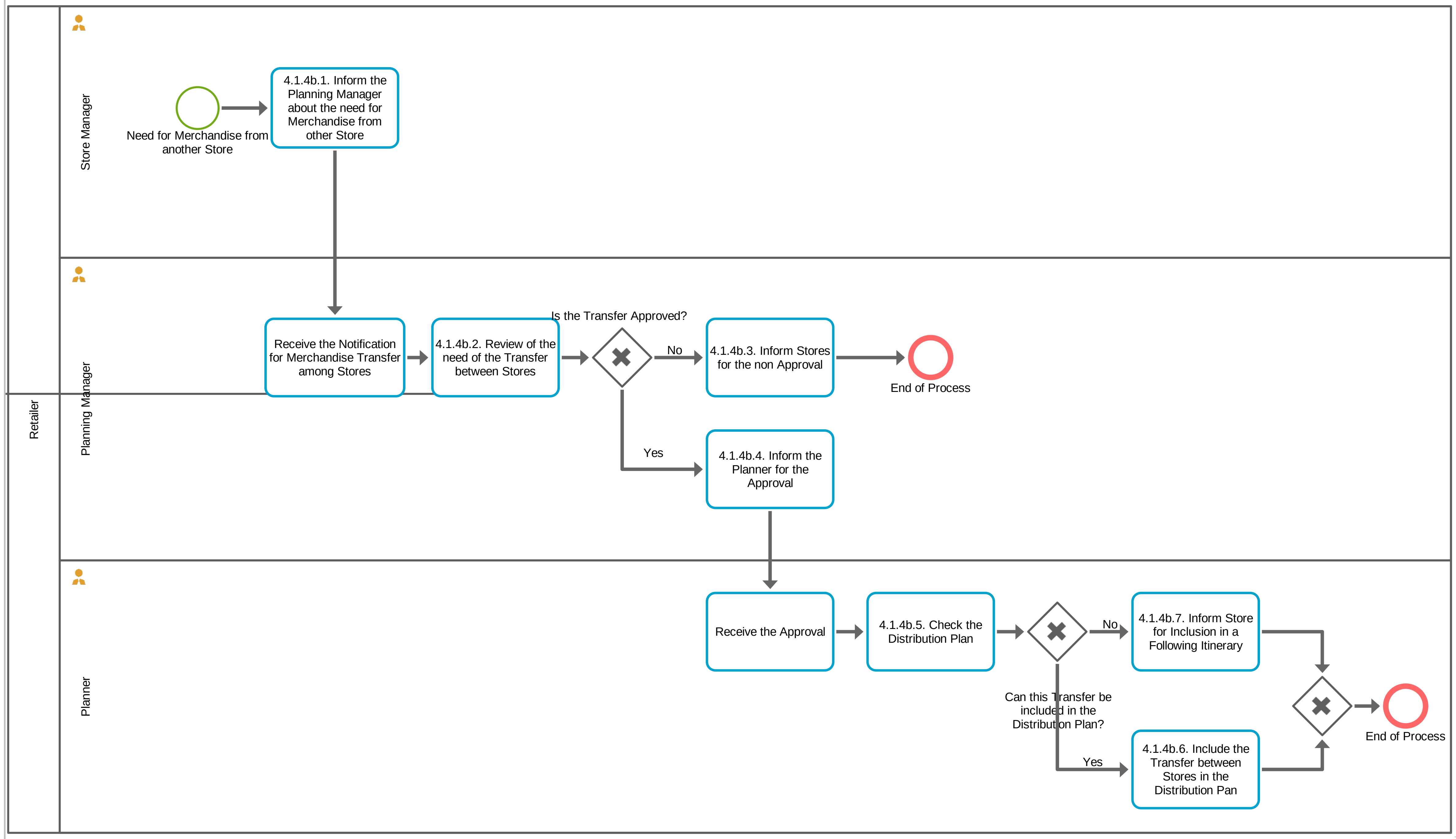


Figure 4.21. Transfer of Merchandise among Stores Process (4.1.4b)

4.3.15.1 Process Prerequisites

- Availability of needed products for one store to another store
- Ability to include transferring among stores to the distribution plan

4.3.15.2 Process Participants

- Planning Manager
- Planner
- Store Manager

4.3.15.3 Periodicity of the process

- Occurs when there is a need for transferring products from a store to another

4.3.15.4 Process Description

This process concerns the transfer or merchandise and constitutes an alternative way of stores replenishment and covering of direct and urgent needs for replenishment of one store by another. It may also occur in the case that the DC have not specific SKUs in stock and there are only in some stores. This is the reason why this process was selected to be depicted as an alternative lower level of merchandise delivering (Process *4.1 Distribute Merchandise*/ Activity 4.1.4).

The process begins with the communication (e-mail) between the Store Manager and the Planning Manager to inform him/her for the need of transferring merchandise to the Store from another Store. The Planning Manager reviews this request and checks its feasibility, taking under consideration specific factors (e.g., cost of transfer, value of products to be transferred). If the Planning Manager does not approve the request, he/she informs the Stores for non-approval and the process ends. If the transfer is approved, the Planning Manager informs the Planner for the approval. The Planner, then, checks the Distribution Plan (Process *3.1.16 Prepare Final Distribution Plan*) in order to decide whether the transfer between the Stores can be included. If the transfer can be served by the current Distribution Plan, it is added by the Planner. If not, the Planner informs the Store Manager that the request will be fulfilled in the next plan.

4.3.15.5 Documents

-

4.3.15.6 Information Systems

-

4.3.15.7 Linked Processes

- 3.1.16 Prepare Final Distribution Plan
- 4.1 Distribute Merchandise

4.3.15.8 Supplementary Diagrams

-

Process 5.1: (Stores) Receive Merchandise from Logistics

Date of First Version: 07/02/2021

Date of Final Version: 23/04/2021

Aim of the Process: Receipt of merchandise coming from warehouse by Stores and the management of received merchandise.

Process Owner: Store

Editor: Konstantinos Stergiou

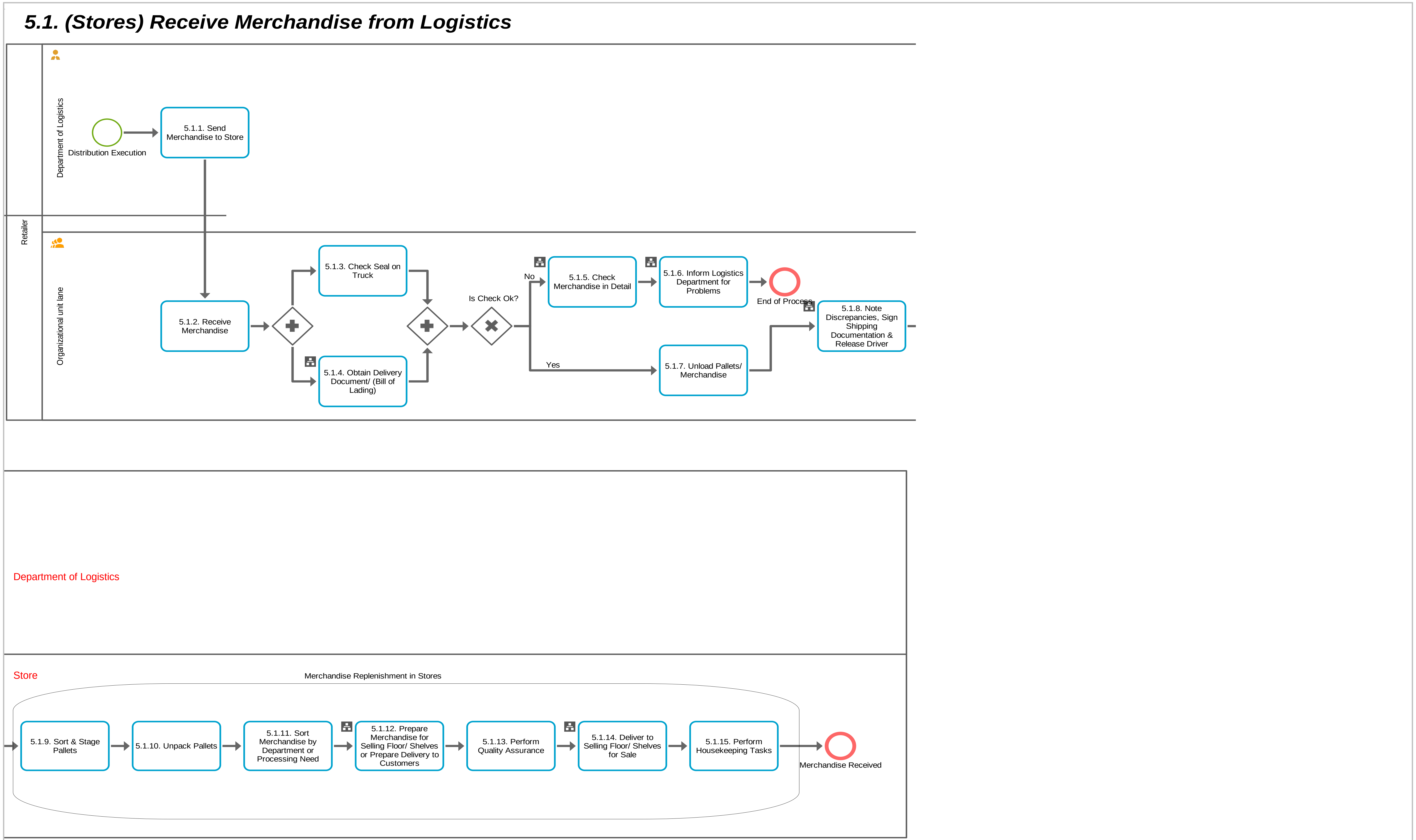


Figure 4.22. (Stores) Receive Merchandise from Logistic Process (5.1)

4.3.16.1 Process Prerequisites

- The delivery occurs in specific time windows depending on store

4.3.16.2 Process Participants

- Department of Logistics
- Store

4.3.16.3 Periodicity of the process

- Depends on the frequency of orders that a Store places or on which day of the week each Store is set to receive merchandise

4.3.16.4 Process Description

The process starts with the shipping of merchandise by the Department of Logistics to Store including the Delivery Document that was described in Processes *4.1 Distribute Merchandise*, *4.1.4a Delivery to Stores Execution*. When the truck with merchandise arrives in the Store, the seal on truck is checked and the Store Manager obtains the Delivery Document. The merchandise is checked in detail according to the order that has been made and the Delivery Document. If there are problems with the merchandise in the first check (pre-unloading), the Store should inform the Department of Logistics. Then, the merchandise (pallets/ boxes) is unloaded for the checking of its quantity and condition. If there are discrepancies in received order in comparison with the shipment documents, then the Store keeps the received products that are ok and should inform Department of Logistics for the discrepancies in order to take the appropriate actions. All the problems and discrepancies of the checks can be notified through ERP system. The receipt is completed with the signing of Delivery Document by the receiver (if the Delivery Document is in Drivers' Tablet, then it is electronically signed by the receiver, an activity supported by the ERP system) and the release of the driver.

The next moves concern the preparation of merchandise to be sold by the Store. The pallets/ boxes are sorted and staged for delivery to selling floor and are unpacked. Then, the unpacked and the contained products are sorted depending on the section of store that should be transferred for replenishment. Appropriate tasks such as assembly or folding, applying merchandise supplies such as security tags, size indicators or hangers are carried out. In particular, for food retail operations must be ensured that perishable products are prepared in accordance with policy and sanitation standards and should be assured that grocery/non-food products are stored and processed as necessary. In this step, the preparation of products for delivery to retailer's customers is also included (Process *5.1.12 Delivery of Products to Customers*) because it was assumed that electronic orders are fulfilled by the region stores of retailer that are (only) specialized in the fulfillment of electronic orders. Another case is the fulfillment of electronic orders by regional DCs. The process followed is the same as in Process 5.1.12. Both cases are in accordance with retailing best practices. After the completion of preparation, the quality of products must be assured by checking all the details, that ensure a product fulfill the specifications and has no defects. This quality assurance activity is the enabling factor for delivering the products to selling floor and stage them or place them to shelves. In food retail operations perishable products should be staged and placed in accordance with sanitation and policy standards. Finally, the receiving area must be cleaned and maintained organized for the next receipts and preparations of products to be delivered on the sell floor for sale (Process *5.1.14 prepare and Execute Sale*). In food retail operations, all freezers, equipment and storage areas of all sections must be maintained.

4.3.16.5 Documents

- Delivery Document

4.3.16.6 Information Systems

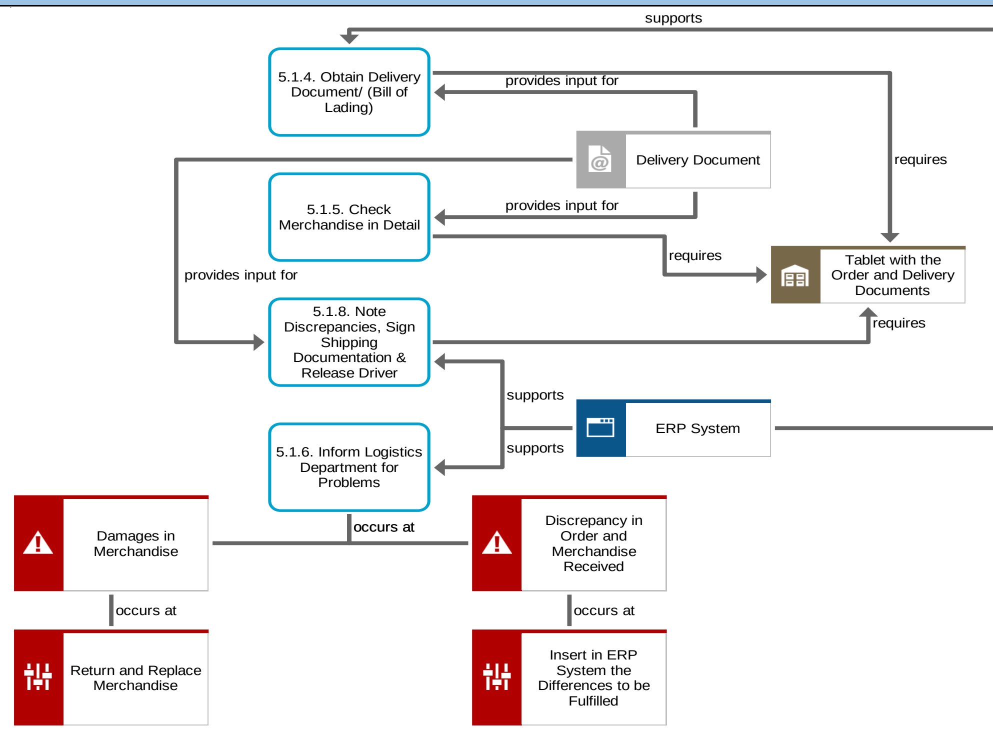
- ERP system

4.3.16.7 Linked Processes

- 4.1 Distribute Merchandise
- 4.1.4a Delivery to Stores Execution
- 5.1.12 Delivery of Products to Customers
- 5.1.14 Prepare and Execute Sale

4.3.16.8 Supplementary Diagrams

Table 4.11. Supplementary Diagrams for (Stores) Receive Merchandise from Logistic Process (5.1)

Activity	Function Allocation Diagram
5.1.4. Obtain Delivery Document/ (Bill of Lading) 5.1.5. Check Merchandise in Detail 5.1.6. Inform Logistics Department for Problems 5.1.8. Note Discrepancies, Sign Shipping Documentation & Release Driver	

Process 5.1.12: Delivery of Products to Customers

Date of First Version: 11/02/2021

Date of Final Version: 29/04/2021

Aim of the Process: Execution of products delivery to customers according to the orders that are received electronically.

Process Owner: Sales Department Employee

Editor: Konstantinos Stergiou

5.1.12 Delivery of Products to Customers

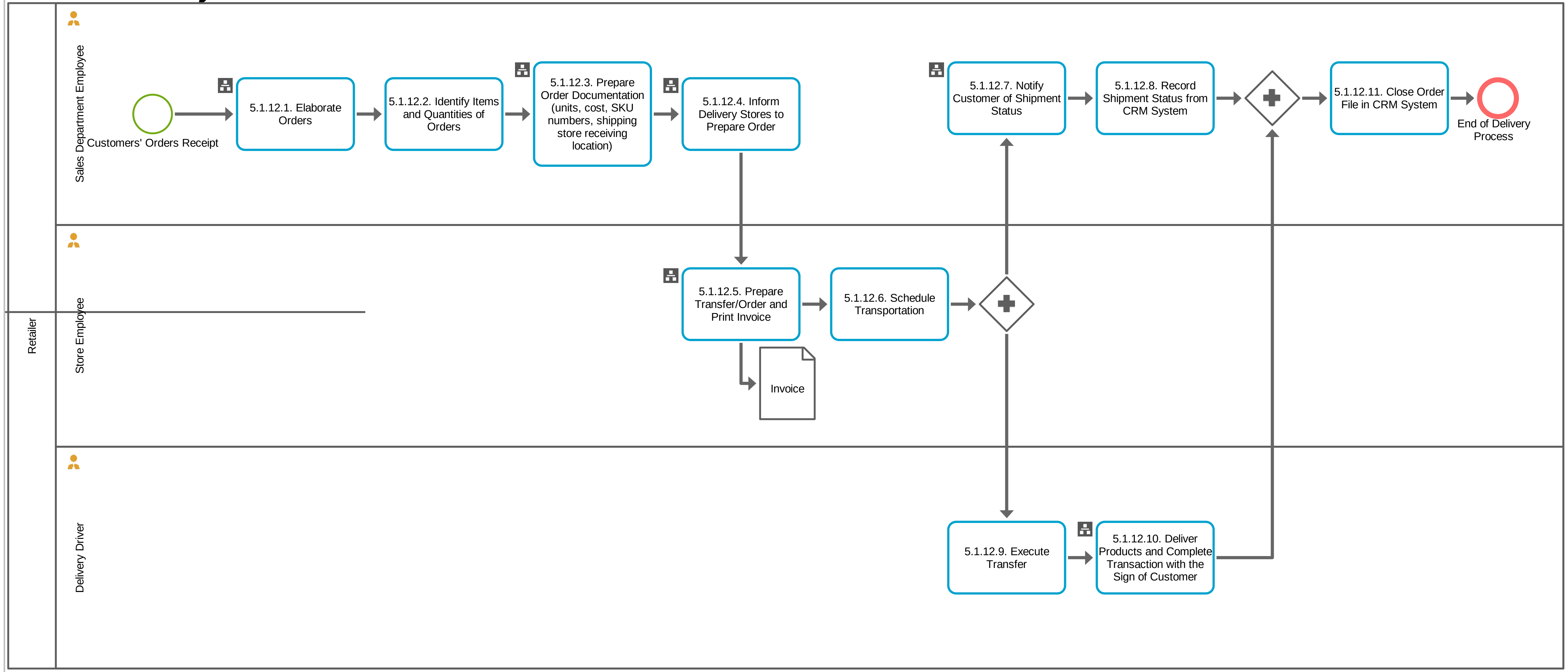


Figure 4.23. Delivery of Products to Customers Process (5.1.12)

4.3.17.1 Process Prerequisites

- Existence of e-commerce channel

4.3.17.2 Process Participants

- Sales Department Employee
- Store Employee
- Delivery Driver

4.3.17.3 Periodicity of the process

- Depends on the frequency of the e-orders that are received by the Department of Sales

4.3.17.4 Process Description

The process starts with the elaboration of the incoming customers' orders by the Sales Department Employee through CRM (Customer Relationship Management) system in order to identify the geographical areas that should be served. Then, the Sales Department Employee identifies the items and quantities of order that have been received. He/She also prepares the order documentation which can be translated in a Delivery Document for the customer including products units, cost, SKU numbers, shipping store, receiving location. The Sales Department Employee informs delivery stores about the orders and gives the appropriate information for the preparation of the order (through ERP).

The Store Employees of delivery stores prepare the order and prints the Invoice (physically or electronically through ERP) including all the information that has been given to them by the Sales Department. Once the order and its documentation are prepared, the transportation to the receiving location is scheduled. The in-transit merchandise should be tracked throughout the transfer process to ensure inventory records are properly updated when the ship-to location receives the merchandise. That is why the Sales Department is informed by Store about the departure of order. The Sales Department Employee also notifies customer for the shipment status and records all the steps of the shipment, through the CRM (Customer Relationship Management) system in order to know the exact flow of the delivery.

At the same time, the Delivery Driver executes the transfer of the order to the customer. The completion of the delivery by the Delivery Driver is occurred with the receipt of products by the customer. The confirmation of the receipt is ensured by the sign of customer (physically or electronically in Driver's tablet). The delivery completion notification is automatically sent to the Sales Department and the Sales Department Employee closes the order file in the CRM system.

4.3.17.5 Documents

- Invoice

4.3.17.6 Information Systems

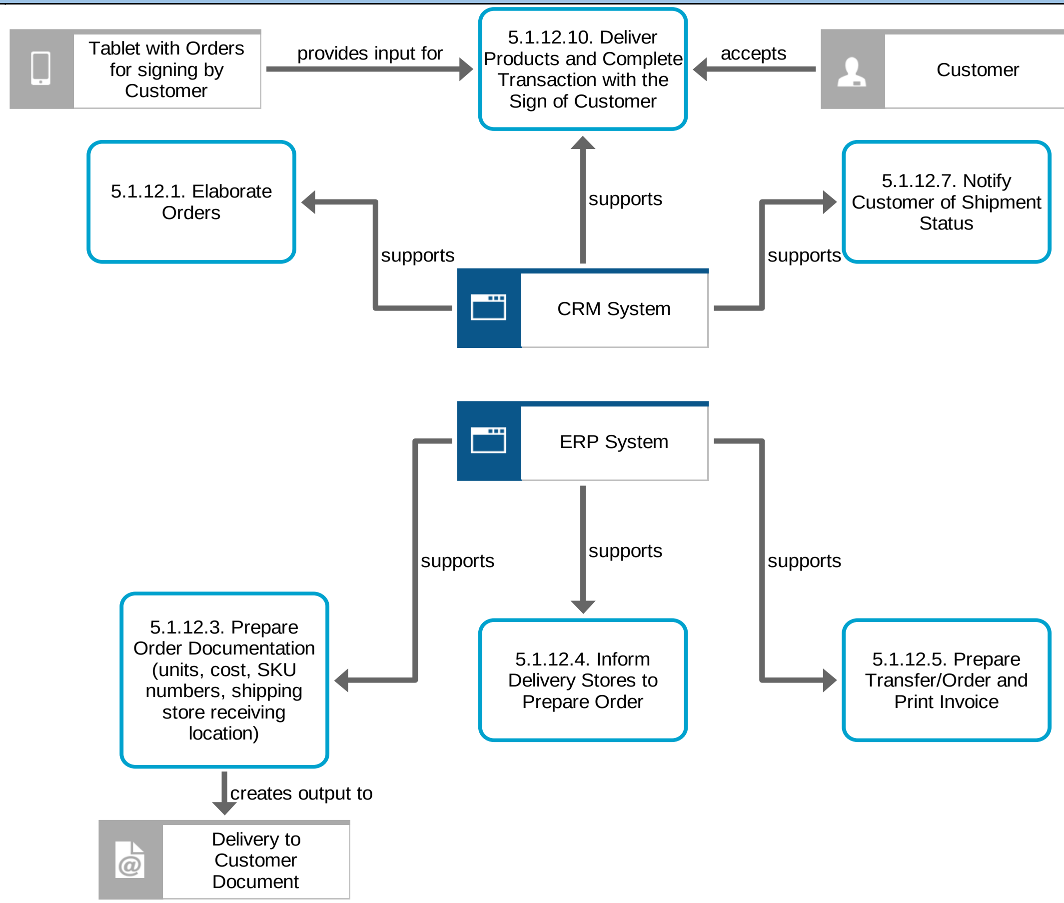
- CRM system
- ERP system

4.3.17.7 Linked Processes

-

4.3.17.8 Supplementary Diagrams

Table 4.12. Supplementary Diagrams for Delivery of Products to Customers Process (5.1.12)

Activity	Function Allocation Diagram
5.1.12.1. Elaborate Orders 5.1.12.3. Prepare Order Documentation (units, cost, SKU numbers, shipping store receiving location) 5.1.12.4. Inform Delivery Stores to Prepare Order 5.1.12.5. Prepare Transfer/Order and Print Invoice 5.1.12.7. Notify Customer of Shipment Status 5.1.12.10. Deliver Products and Complete Transaction with the Sign of Customer	

Process 5.1.14: Prepare and Execute Sale

Date of First Version: 16/02/2021

Date of Final Version: 03/05/2021

Aim of the Process: Preparation of products to be sold to customers by the Store and execution of the activities that are results of the sale.

Process Owners: Store Employees, Cashier

Editor: Konstantinos Stergiou

5.1.14. Prepare and Execute Sale

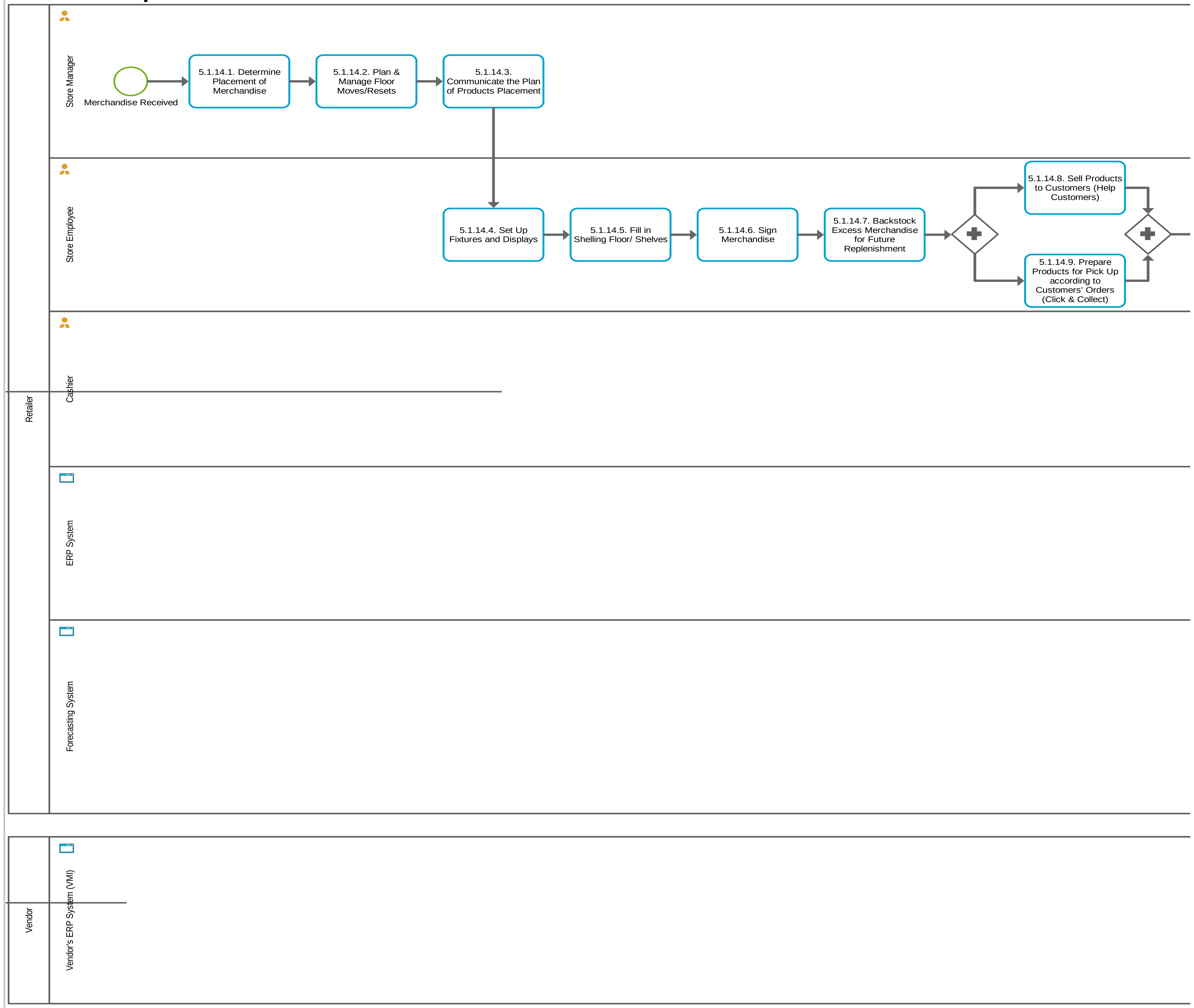
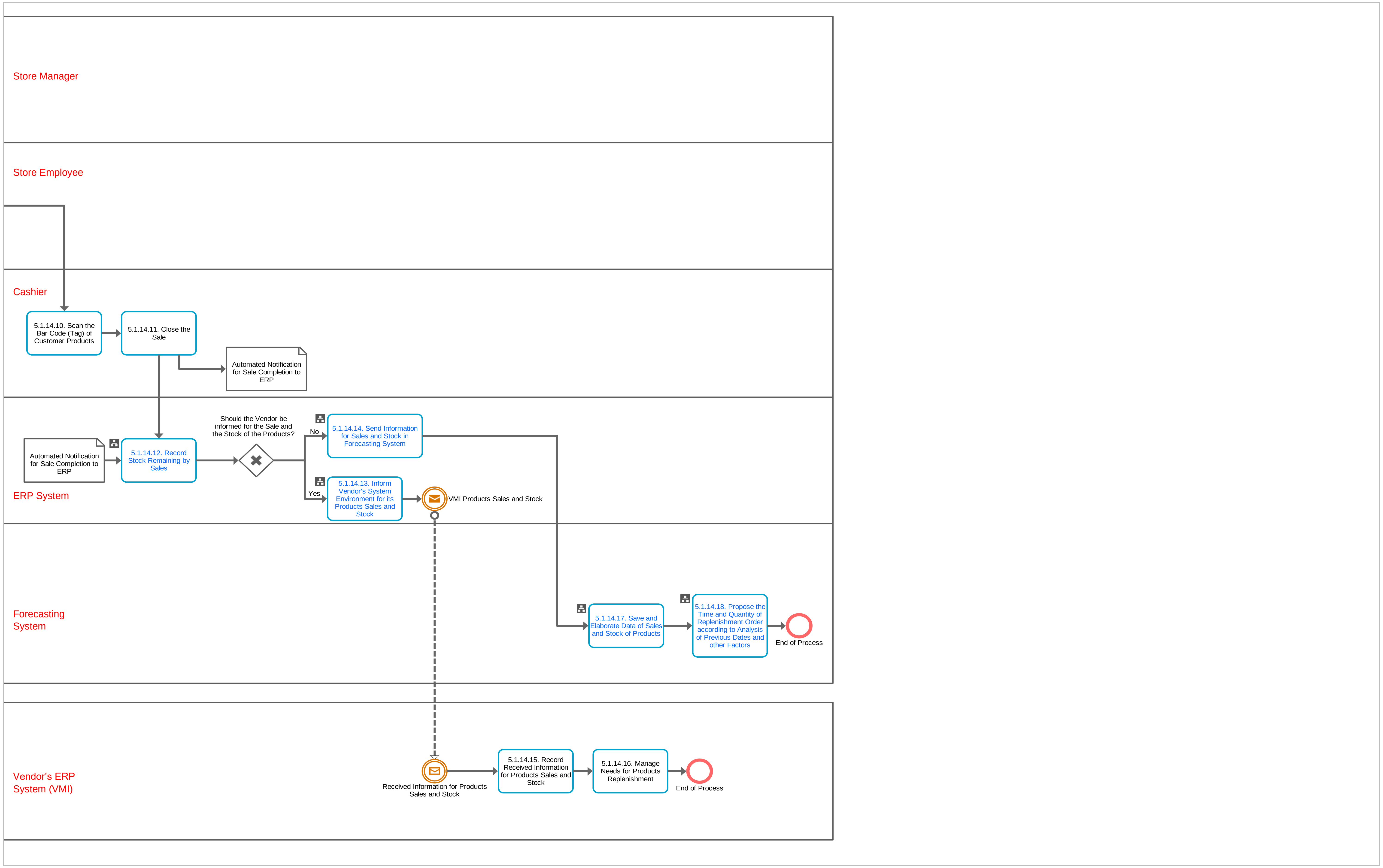


Figure 4.24. Prepare and Execute Sale Process (5.1.14)


Store Manager
Store Employee
Cashier
5.1.14.10. Scan the Bar Code (Tag) of Customer Products
5.1.14.11. Close the Sale
Automated Notification for Sale Completion to ERP
ERP System
Automated Notification for Sale Completion to ERP
5.1.14.12. Record Stock Remaining by Sales
Should the Vendor be informed for the Sale and the Stock of the Products?
No
Yes
5.1.14.14. Send Information for Sales and Stock in Forecasting System
5.1.14.13. Inform Vendor's System Environment for its Products Sales and Stock
VMI Products Sales and Stock
Forecasting System
5.1.14.17. Save and Elaborate Data of Sales and Stock of Products
5.1.14.18. Propose the Time and Quantity of Replenishment Order according to Analysis of Previous Dates and other Factors
End of Process
Vendor's ERP System (VMI)
Received Information for Products Sales and Stock
5.1.14.15. Record Received Information for Products Sales and Stock
5.1.14.16. Manage Needs for Products Replenishment
End of Process

4.3.18.1 Process Prerequisites

- Existence of Forecasting Information System connected with sales
- VMI operation
- Receipt of merchandise or existence stocked merchandise

4.3.18.2 Process Participants

- Sales Department Employee
- Cashier
- Store Manager

4.3.18.3 Periodicity of the process

- Depends on the frequency of the replenishment and selling of each SKU

4.3.18.4 Process Description

The process starts after the receipt of merchandise (Processes *5.1 (Stores) Receive Merchandise from Logistics, 2.1 Receive Merchandise from Vendor*) with the determination of the merchandise placement by the Store Manager. The determination is based on planogram, taking into account specific store restrictions (space). The Store Manager also plans large floor movements or seasonal resets in advance and compiles a list of fixtures, displays needed and staffing requirements. Then, the Plan of Product Placement is communicated by the Store Manager to Store Employees in order to take the appropriate actions. The Store Employees should set up new fixtures or shelf allocation according to store layout and set up display, such as end-caps, mannequins, point-of-purchase, etc. For food retail operations, Store Employees have to organize and manage vendor sponsored end-caps and must be ensured that Vendors maintain product support throughout the promotion. The Store Employees, then, fill in the selling floor/shelves with products in the right position. On a continuing basis, the selling floor should be filled-in from backstock to maintain sizes and overall presentation. (In some cases, Vendor may stock and maintain their own product sales area). The new products have to be signed and get price tickets (for special offers or not). After the merchandise has been replenished by the Store Employee, the excess merchandise is back-stocked for future replenishment.

The Store Employees, apart from their replenishment responsibilities, have to help the customers in choosing and finding the right products, and inform customers about promotional actions or prepare the products that have been ordered by customers (e-orders) for pick-up by stores. In both cases, the products are following the same flow for the completion of the sale in the cash desk. The cashier scans the bar code (tag) of the products for the identification of the SKU and closes the sale with the customer after the receiving of the payment (along with other activities like scanning membership card and sales coupons).

The closing of sale enables a series of activities that are executed automatically with the cooperation of different information systems. The sale is recorder by the ERP system and the stock of product is updated. If the stock of specific categories of merchandise is managed by Vendor (Vendor Managed Inventory-VMI), then the ERP system informs the system of Vendors for the sales of their products. The Vendor's ERP system receives continuously information about sales and stock of its merchandise and from there the Vendor can manage the needs and send the appropriate number of products according to the needs for replenishment and the contracts that have been signed with the Retailer. If the merchandise replenishment is not following the VMI rational, then the ERP system of the Retailer, which communicates with the Forecasting system, sends the data of sales and stock for the elaboration of them by the Forecasting system (e.g., utilizing machine-learning algorithms). Subsequently, the Forecasting system proposes the right quantity and time of replenishment orders, according to the analysis of previous dates and other factors such as trends, seasonality and demand influencing factors, such as promotions or specific holidays with significant impact on the sales curve, even the weather forecast.

4.3.18.5 Documents

-

4.3.18.6 Information Systems

- ERP system
- Forecasting system
- Vendor's ERP system

4.3.18.7 Linked Processes

- 2.1 Receive Merchandise from Vendor
- 5.1 (Stores) Receive Merchandise from Logistics

4.3.18.8 Supplementary Diagrams

-

4.3.19 Manage Reverse Logistics Process (6.1)

Process 6.1: Manage Reverse Logistics

Date of First Version: 18/02/2021

Date of Final Version: 16/05/2021

Aim of the Process: Management and redirection of the returned merchandise by Stores to Logistics.

Process Owner: Department of Logistics

Editor: Konstantinos Stergiou

6.1. Manage Reverse Logistics

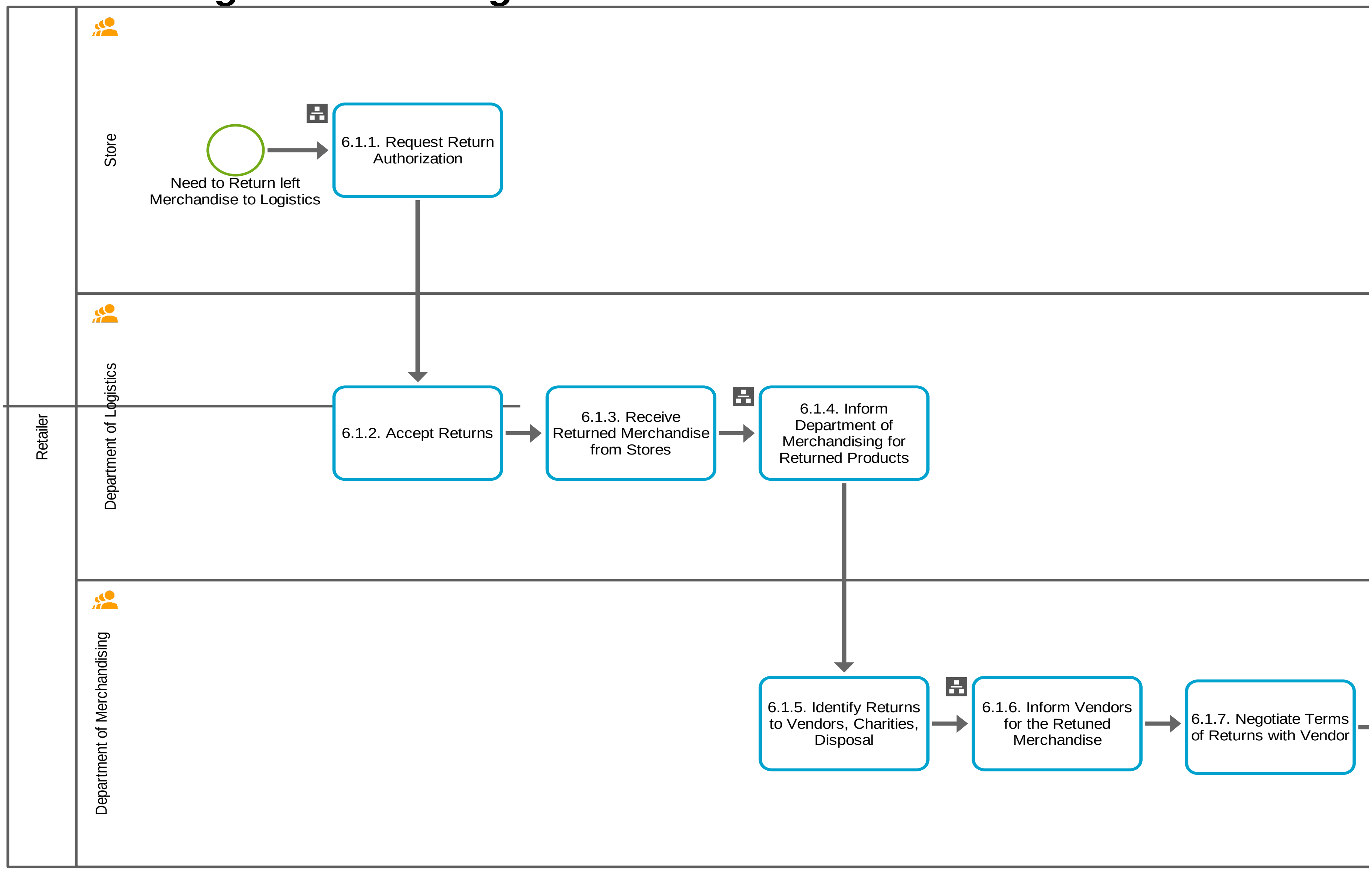
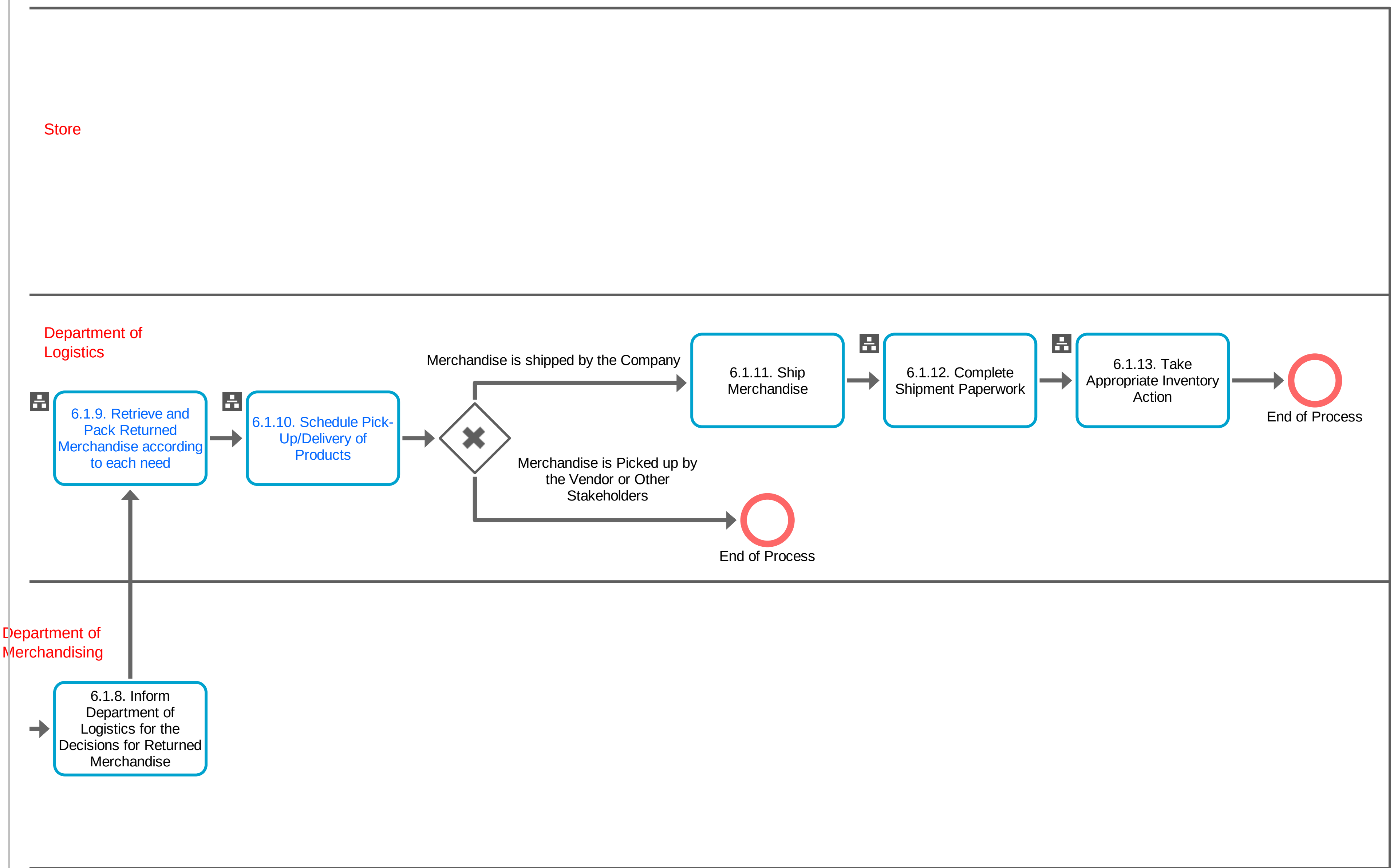


Figure 4.25. Manage Reverse Logistics Process (6.1)


Store
Department of Logistics
Merchandise is shipped by the Company
6.1.11. Ship Merchandise
6.1.12. Complete Shipment Paperwork
6.1.13. Take Appropriate Inventory Action
End of Process
6.1.9. Retrieve and Pack Returned Merchandise according to each need
6.1.10. Schedule Pick-Up/Delivery of Products
Merchandise is Picked up by the Vendor or Other Stakeholders
End of Process
Department of Merchandising
6.1.8. Inform Department of Logistics for the Decisions for Returned Merchandise

4.3.19.1 Process Prerequisites

- Existence and availability of a dedicated space into the warehouse for the deposition and management of returned merchandise

4.3.19.2 Process Participants

- Department of Logistics
- Department of Merchandising
- Store

4.3.19.3 Periodicity of the process

- Depends on the frequency that there is a need for merchandise returning to the warehouse

4.3.19.4 Process Description

The first step of the process is the request by the Stores for return authorization to the Department of Logistics. The returns can be overstocked, unsold, damaged products, (expired date products for food sector) etc. The Department of Logistics checks the request and decides for its acceptance. The Department of Logistics, then, receives the returned merchandise from Stores along with Delivery Document of Returned Products (can be transferred electronically through ERP) and informs the Department of Merchandising (could be through ERP) for the returned products.

After that, the Department of Merchandising decides what to do with the returned products. The decision could be the donation of products to charities or the returning of them to Vendors (alternatively, the products can be transferred to other retailers specialized in post-selling of used or defective but operational products). If the merchandise is contacted to be returned to Vendors, the Department of Merchandising informs Vendors for the returned merchandise and negotiate the terms of returns with Vendors, in the case that there are differences in the quantity or returned merchandise against the expected one. Then, the Department of Merchandising informs the Department of Logistics about the decisions that were received for the returned merchandise in order to be categorized and prepared for each case.

The employees of the Department of Logistics retrieve the merchandise from the storage of returned products and pack the products accordingly. Subsequently, the pick-up and delivery of merchandise is scheduled by the Department of Logistics based on the contracts with Vendors and on the destination of the merchandise. If the returned products are picked up by Vendors or other Stakeholders, then the process ends for the Department of Logistics. If merchandise is being returned to a Vendor, it may be able to go out on a truck that delivered supplies from that particular Vendor. If the returned merchandise is shipped by the Retailer, then the Department of Logistics carries out the shipping. The appropriate mode of transportation should be selected. The shipment should be come along with the necessary paperwork, such as the Loading Form of Returned Products (through DMS). Finally, the Department of Logistics should inform the WMS about the disposition of the returned products that had been stored (this step can be executed automatically using IoT sensors or RFID technology which will also permits the tracking of the route of the returned products for ensuring that they reached their final destination).

4.3.19.5 Documents

- Delivery Document of Returned Products
- Loading Form of Returned Products

4.3.19.6 Information Systems

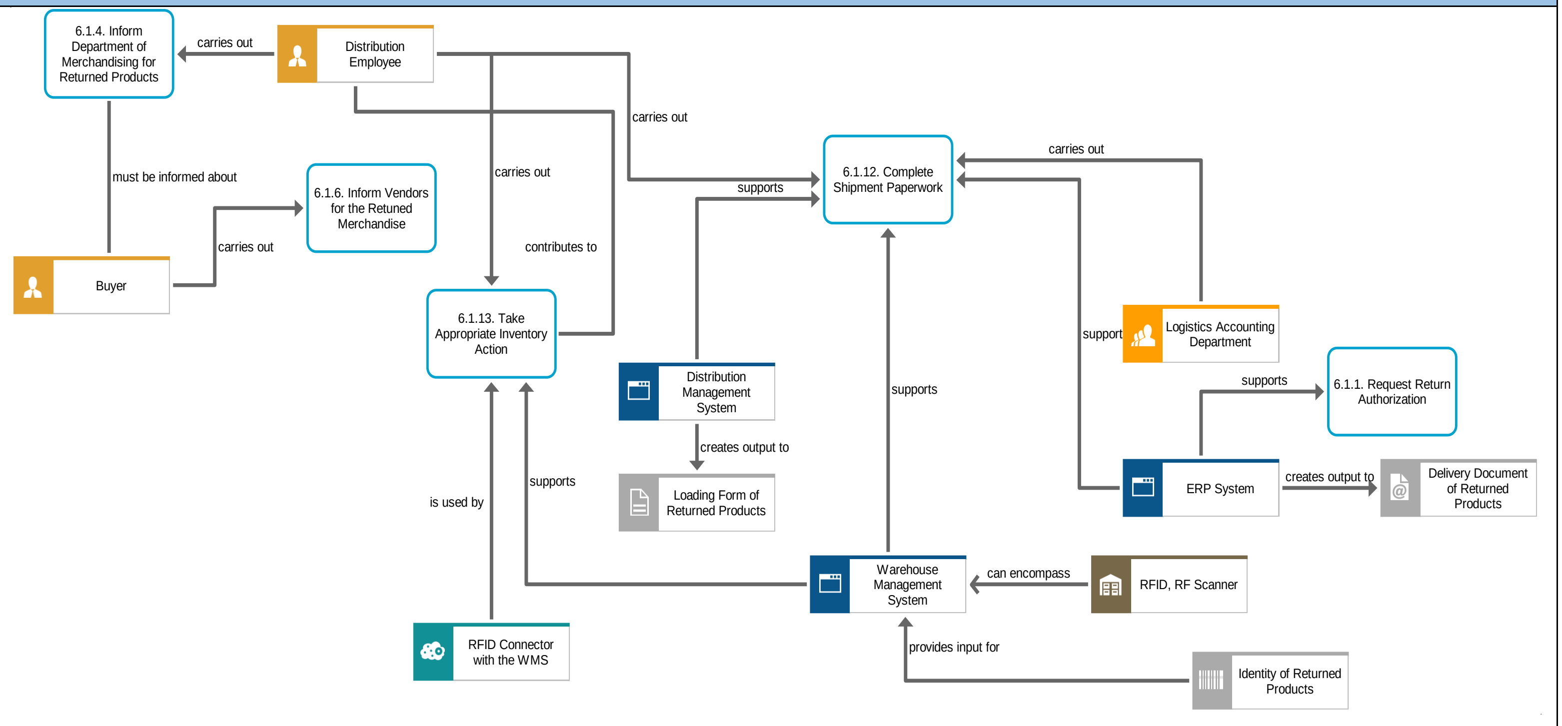
- ERP system
- WMS
- DMS

4.3.19.7 Linked Processes

-

4.3.19.8 Supplementary Diagrams

Table 4.13. Supplementary Diagrams for Manage Reverse Logistics Process (6.1)

Activity	Function Allocation Diagram
6.1.1. Request Return Authorization 6.1.4. Inform Department of Merchandising for Returned Products 6.1.6. Inform Vendors for the Retuned Merchandise 6.1.12. Complete Shipment Paperwork 6.1.13. Take Appropriate Inventory Action	

4.4 LSS Initiatives

The configuration of the supply chain processes was followed by the next part of the LSS RSCPR which suggests the implementation of DMAIC and specific LSS tools in every DMAIC phase in order to propose specific LSS initiatives for the improvement of operations. These tools are presented in **Figure 4.26**. Their selection took into account their suitability for use in the business processes of the supply chain of the retail sector, as well as their ease of use by process participants (after a short period of training), particularly in the Define phase which should easily trigger the improvement project by defining the problems. All the phases, apart from the Improve phase which encompasses a free selection of improvement actions, include a range of tools from which the companies can select those matching to their project needs. An emphasis has been given to the statistical tools, such as ANOVA (or Chi-square), 2-sample t-test (or proportion test), and correlation and regression analysis because they permit the comparison among data of different samples, which is an important factor of analysis for retailers, as they need to compare the operation of different DCs or the discrepancies among different product categories. In addition, in both Measure and Analyze phases, the utilization of plots and charts, such as histograms, boxplots, time series plots, pareto diagram, or stacked bar charts, are proposed for the facilitation of the depiction of a big volume of data that should be collected for the justification of each improvement action.

Every LSS initiative is also an improvement action in the phase of Improve. LSS initiatives were selected to confront the problems and needs of retail companies in the most important activities of their processes. The selection of these activities was based on the suggestions of the companies that participated in the development of this reference model, as well as on the areas that improvements can have a positive impact according to the recognized best practices worldwide. LSS initiatives propose process changes, improvements based on technological solutions and Industry 4.0 principles with the insertion of automations and IoT sensors in order to make processes more transparent and efficient, the introduction of collaborative platforms connecting the stakeholders of the supply chain, the integration of information systems, and the utilization of advanced algorithms in concrete activities. These improvements proposed in the Improve phase are a result of the analysis that has been undertaken in the previous steps starting from the Define phase. In this reference model, with help of LSS tools, the steps of Define phase that are described show how and where to identify specific faults, dysfunctions and problems, factors affecting cost, causes of delays in critical activities and KPIs, based on empirical knowledge and process mapping/ modeling. The Measure phase, that follows, proposes the measurement and collection of data relevant to the problems which have been identified in the Define phase. Subsequently, the data and information are elaborated in the Analyze phase in order to find out the effect of specific factors to processes and this analysis leads to the appropriate improvements. The overview of DMAIC steps according to the LSS RSCPR is presented in **Table 4.14** which describes the actions undertaken in order to recognize problems (Define), measure them (Measure), analyze and elaborate the collected data (Analyze), develop and implement changes (Improve) and retain the efficiency and effectiveness of improvements (Control).

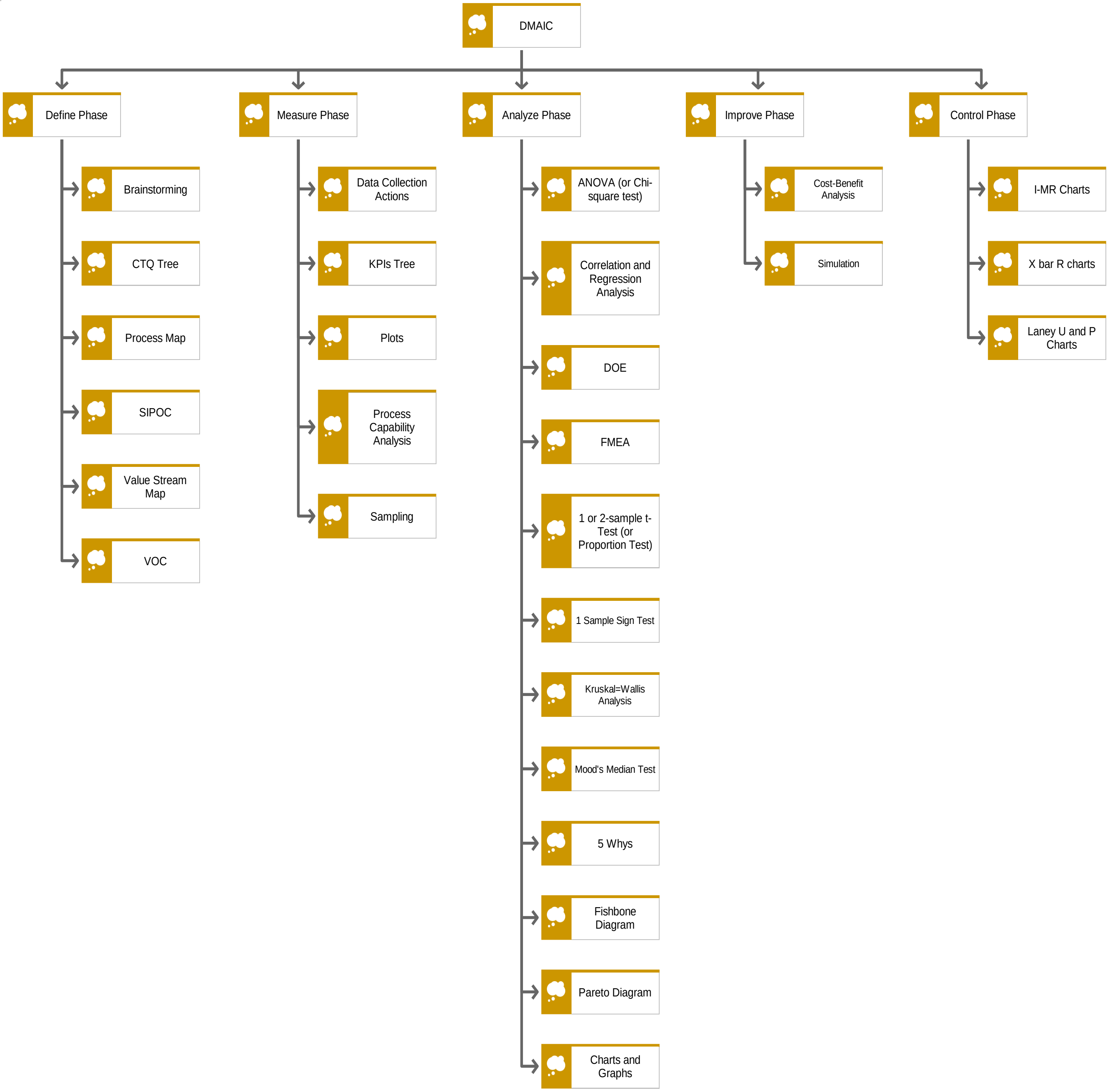


Figure 4.26. LSS tools proposed in LSS RSCPR categorized in DMAIC phases

Table 4.14. Comprehensive definition of the guidelines proposed for the DMAIC deployment in LSS improvement projects

Define Phase	Measure Phase	Analyze Phase	Improve Phase	Control Phase
▪ Identify specific faults, problems and dysfunctions and causes of delays in critical activities ▪ Determine KPIs ▪ Define factors affecting cost	▪ Measure process times and delays ▪ Measure KPIs ▪ Calculate cost categories based on each process ▪ Calculate the number of faults in specific activities	▪ Utilise tools to examine the root causes of the problem, faults and dysfunctions ▪ Analyze data to identify the (quantitative) correlation between causes and problems	▪ Develop improve actions (LSS initiatives) according to the needs of activities related to them ▪ Implement changes and improvements	▪ Verify improvements ▪ Develop and apply control plans ▪ Develop procedures for the retainment of improvements

The aim of the proposed LSS initiatives is to adopt process changes and technological applications for cost reduction, improved services, and higher operational efficiency. **Table 4.15** summarizes and represents the LSS initiatives proposed for each activity or group of activities (processes and activities including only LSS initiatives are presented) that help in the improvement of the whole process and, as a consequence, in the improvement of the whole supply chain. Every LSS DMAIC project can include one or more LSS initiatives based on the available resources, the commitment, and the capacity of each company in CI.

Table 4.15. Description of LSS initiatives proposed by the LSS RSPCR correlated to the activities that can improve

Processes /Subprocesses	Activities with LSS Initiatives	LSS Initiatives
1.1 Forecasting	1.1.3. Calculate Sales Forecast	▪ Utilise advanced forecasting algorithms for more accurate determination of demand ▪ Introduce Sales and Operations Planning (demand, supply, finance) ▪ Upgrade Information System (IS) to utilise Machine Learning (ML) and Artificial Intelligence (AI) technology for more accurate forecasting (factors taken under consideration: past sales, trends, seasonality, and demand influencing factors, such as promotions or specific holidays with significant impact on the sales curve) ▪ Utilise IoT objects communicating with the forecasting IS for stock recording ▪ Use RFID technology to track merchandise through ERP or track merchandise with information sent by vendor in order to know the orders in progress
1.2 Purchase Merchandise	1.2.5. Create PO 1.2.10. Send PO to Vendor using ERP system	▪ Introduction of suitable stock replenishment algorithms in order to improve quantities of order ▪ Record real-time stock (through IoT technology) to configure the right PO and adjust PO quantity according to the principles of JIT ▪ Insert automated PO function in ERP system incorporated with the Forecasting System

Processes /Subprocesses	**Activities with LSS Initiatives**	**LSS Initiatives**
1.3 Maintain PO	1.3.1. Track Order Status	▪ Manage POs through ERP system and track the merchandise connected with each PO (RFID)
2.1 Receive Merchandise from Vendor	2.1.3. (Logistics) Obtain & Record Shipping Notification	▪ Connect vendor's and company's ERP for better communication and tracking of incoming merchandise ▪ Introduction of E-Procurement collaborative platform for the company and its vendors
	2.1.5. Schedule Appointment with Vendors/Carriers for Merchandise Receiving 2.1.8. Assign Trucks to Docks 2.1.28. (Stores) Obtain & Record Shipping Notification	▪ Prepare (automated) assignment of trucks to docks for loading and unloading facilitation for merchandise that is directly distributed without keeping it stored
	2.1.10. Unload, Scan and Count Cartons	▪ Connect WMS with RFID Scanners and counting devices for automatically inserting information about received merchandise in order to know the ID of each product and where it will be placed in the DC ▪ Establish specific sections of the Warehouse for merchandise receipt and organize them according to the needs of the receipt activities
	2.1.20. Determine Put-away Location 2.1.21. Stage Merchandise for Appropriate Zone-Moves 2.1.23. Transport Merchandise to Storage 2.1.24. Confirm/Adjust Location 2.1.25. Record Stock Location	▪ Change or reconfigure storage area location to reduce distances in warehouse and facilitate movements in it ▪ Use IoT sensors to auto-measure (temperature, humidity, light) and warn for inappropriate storage conditions ▪ Use autonomous vehicles for merchandise transportation to storage area along with IoT technology to transfer information in WMS ▪ Use WMS to record stock merchandise location
	2.1.22. Flow-through Cross-dock Merchandise	▪ Change or reconfigure processes in order to include or increase the level of cross-docking activities ▪ Use autonomous vehicles for transferring pallets (cost-cutting) and track their position anytime in the DC via IoT network connected with the WMS ▪ Scan products with RFID sensors during unloading to track merchandise in every step of the cross-docking process through the WMS ▪ Collaboration with the vendor for better preparation and planning through ERP or E-Procurement collaboration platform ▪ Design cross-docking facilities layout and assign specific places to inbound and outbound trucks ▪ Determine appropriate safety stock rules in order to cover cross-docking faults or delays

Processes /Subprocesses	**Activities with LSS Initiatives**	**LSS Initiatives**
2.1.22 Cross-Docking	2.1.22.5. Check and Adjust Order Delivery Details along with the Vendor	▪ Collaboration with the vendor for better preparation and planning through ERP or E-Business collaborative platform
	2.1.22.8. Assign Docks to Inbound and Outbound Trucks	▪ Connect vendor's and company's ERP for better communication and tracking of incoming merchandise ▪ Prepare (automated) assignment of trucks to docks for loading and unloading facilitation for merchandise that is directly distributed without keeping it stored
	2.1.22.15. Unload Pallets/ Merchandise	▪ Connect WMS with RFID Scanners and counting devices for automatically inserting information about received merchandise in order to know the ID of each product and where it will be placed in the DC ▪ Establish specific sections of the Warehouse for merchandise receipt and organize them according to the needs of the receipt activities
	2.1.22.18. Track the Route of the Pallets/ Merchandise from Receiving to Dispatch	▪ Use autonomous vehicles for transferring pallets (cost-cutting) and track their position anytime in the DC via IoT network connected with the WMS ▪ Scan products with RFID sensors during unloading to track merchandise in every step of the cross-docking process through the WMS
3.1 Picking, Packing and Shipment Preparation	3.1.12. Pick Products 3.1.15. Transport Merchandise to Pack/Ship Area 3.1.16. Assemble Order Into Shipping Container/ Pallet	▪ Utilise autonomous vehicles and Robots for picking, transportation to packing area and packing along with IoT sensors for the communication of autonomous vehicles and robots with the WMS ▪ Utilise convey belts for transportation from picking to packing area ▪ Reconfiguration of picking and packing area/ lanes in terms of space, distances, and proximity for better performance ▪ Use Augmented Reality (AR) applications for navigation in the DC and train employees to this picking and packing method ▪ Use RFID technology to track the picked and packed products for each order
3.1.1 Order Sending from Stores to Logistics	3.1.1.7. Enter Order to the System	▪ Introduction of suitable stock replenishment algorithms in order to improve quantities of orders ▪ Introduction of the function of auto-order approved and corrected by the store manager (connected with the forecasting system) to reduce faults, delays, and costs (factors taking under consideration for auto-order: least stock quantity, shelf space for each product category,

Processes /Subprocesses	**Activities with LSS Initiatives**	**LSS Initiatives**
		frequency of receiving each category of products, sales average quantity, promotions) ▪ Use IS (ERP) to track the precise stock for accurate orders
3.1.2 Order Receiving and Distribution Preparation	3.1.2.6. Plan Back-Hauling and Empty Pallets Returning	▪ Increase (or decrease) the proportion of back-hauling to meet the cost target ▪ Track back-hauling merchandise route (or empty pallets) using scanning technology (RFID, RF) through ERP ▪ Auto-programming of back-hauling by the Distribution Management System (DMS) in the routing/ distribution plan
3.1.2.6 Back-hauling Planning	3.1.2.6.8. Add Back-Hauling and Empty Pallets Return to the Plan for each case	▪ Generate Distribution Plan including auto-generated Back-Hauling needs
3.1.16 Prepare Final Distribution Plan	3.1.16.7. Create the Final Distribution Plan through the System (after Picking Completion)	▪ Utilise suitable advanced algorithms for the generation of the optimal routing plan of the trucks ▪ Add the function of proposed auto-generated Final Distribution Plan based on all the needs that have been inserted in the Distribution Management System (routing, cross-docking, back-hauling, reverse logistics)
3.1.19 Load Trucks	3.1.19.8. Scan (RF, RFID) and Confirm the Merchandise to be loaded 3.1.19.9. Load Trucks	▪ Use autonomous vehicles or human-driven vehicles (with IoT Sensors to connect with WMS) for loading ▪ Utilise RFID technology connected with the WMS to record the whole process ▪ Organise loading area to be convenient for loading and assign docks to trucks according to the needs of the loading process (auto-assignment using WMS)
4.1 Distribute Merchandise	4.1.5. Record Shipment	▪ Track the position of trucks using GIS system by both DC and stores ▪ Keep information in Distribution Management System (DMS) for the orders that are transferred in each truck based on the data of the loading process (in real time) ▪ Get informed for each order transfer completion through the DMS
5.1.14 Prepare and Execute Sale	5.1.14.12. Record Stock Remaining by Sales	▪ Use IS (ERP) to track the precise stock for accurate orders
	5.1.14.13. Inform Vendor's System Environment for its Products Sales and Stock	▪ Improve ERP functionality to share specific information with vendors' ERP about their product sales and stock. Vendors will know exactly the accurate order needed for the retailer and will get benefited by organizing their

Processes /Subprocesses	Activities with LSS Initiatives	LSS Initiatives
		own inventory and production. With this technique, the JIT method can be favoured. – Introduction of e-business collaborative platform.
	5.1.14.14. Send Information for Sales and Stock in Forecasting System	▪ Utilise IoT objects communicating with the forecasting IS for stock recording
	5.1.14.17. Save and Elaborate Data of Sales and Stock of Products	▪ Upgrade Information System (IS) to utilize Machine Learning (ML) and Artificial Intelligence (AI) technology for more accurate forecasting (factors taken under consideration: past sales, trends, seasonality, and demand influencing factors such as promotions or specific holidays with significant impact on the sales curve) ▪ Utilise IoT objects communicating with the Forecasting IS for stock recording ▪ Connect forecasting system to ERP to collect information about stock ▪ Utilise cloud computing for the collection of data by store smart sensors recording the shopping journey (e.g., store traffic, interest about specific products categories by the customers, promotions effectiveness, shopping times, suitability of store layout in finding products) for the analysis of the consumers' behaviour in order to be used in forecasting and personalization of offers
	5.1.14.18. Propose the Time and Quantity of Replenishment Order according to Analysis of Previous Dates	▪ Insert automated PO function in ERP System incorporated into the forecasting system
6.1 Manage Reverse Logistics	6.1.9. Retrieve and Pack Returned Merchandise according to each need 6.1.10. Schedule Pick-Up/Delivery of Products	▪ Use autonomous vehicles or Augmented Reality (AR) applications connected with the WMS via IoT sensors to receive information of picking and packing returned merchandise for each need ▪ Track and record returned merchandise through WMS to inform the vendor (through ERP) for returns and when the products will be ready for receiving (reduce storage space in the DC)

The analytical description of the LSS initiatives and the diagrams of LSS improvement areas are presented in the next pages. Each EPC diagram which depicts the steps of DMAIC phases implementation is connected with the diagram of proposed LSS tools, through the Knowledge Category objects of each phase. The proposed utilization of tools and details about improvement actions are also described in the accompanied text. A crucial issue that concerns Analyze phase is that the utilization of quantitative tools (1 or 2-sample t-test, ANOVA, Correlation and Regression Analysis) except 1 sample sign test, Kruskal-Wallis analysis and Mood's median test, requires the data to be normally distributed or to be transformed to follow the normal distribution in order to extract correct results for the mean and the standard deviation of samples. If the data are not following the normal distribution and cannot been transformed, then the 1 sample sign test, Kruskal-Wallis analysis and Mood's median test can be used as they analyze the data based on median. Moreover, in the Analyze phase, DOE can be used in all the cases if the project team analyzes a process affected by several factors and desires to "experimentally" extract conclusions about the effect of them in the activities. However, this method/tool is very costly, as it requires to test the process in many different conditions and states and for this reason, it should be carefully designed before its utilization. In addition, specific tools are not suggested for Define and Measure phases, as this is more of a subjective decision by the company in order to detect a problem and find a convenient way to collect the appropriate data according to the proposals of the model. Finally, in the Improve phase the remeasurement of the variables that the company wants to improve or the simulation of the system after the improvement with the new data is very important in order to understand whether the LSS initiative led to actual positive impact. A Cost-Benefit Analysis is also very important in this phase, as it will help to infer whether the investment in a technological solution will be effective, or another improvement action would be more appropriate.

4.4.1 *Forecasting LSS Initiatives*

4.4.1.1 LSS Improvement Area Diagram

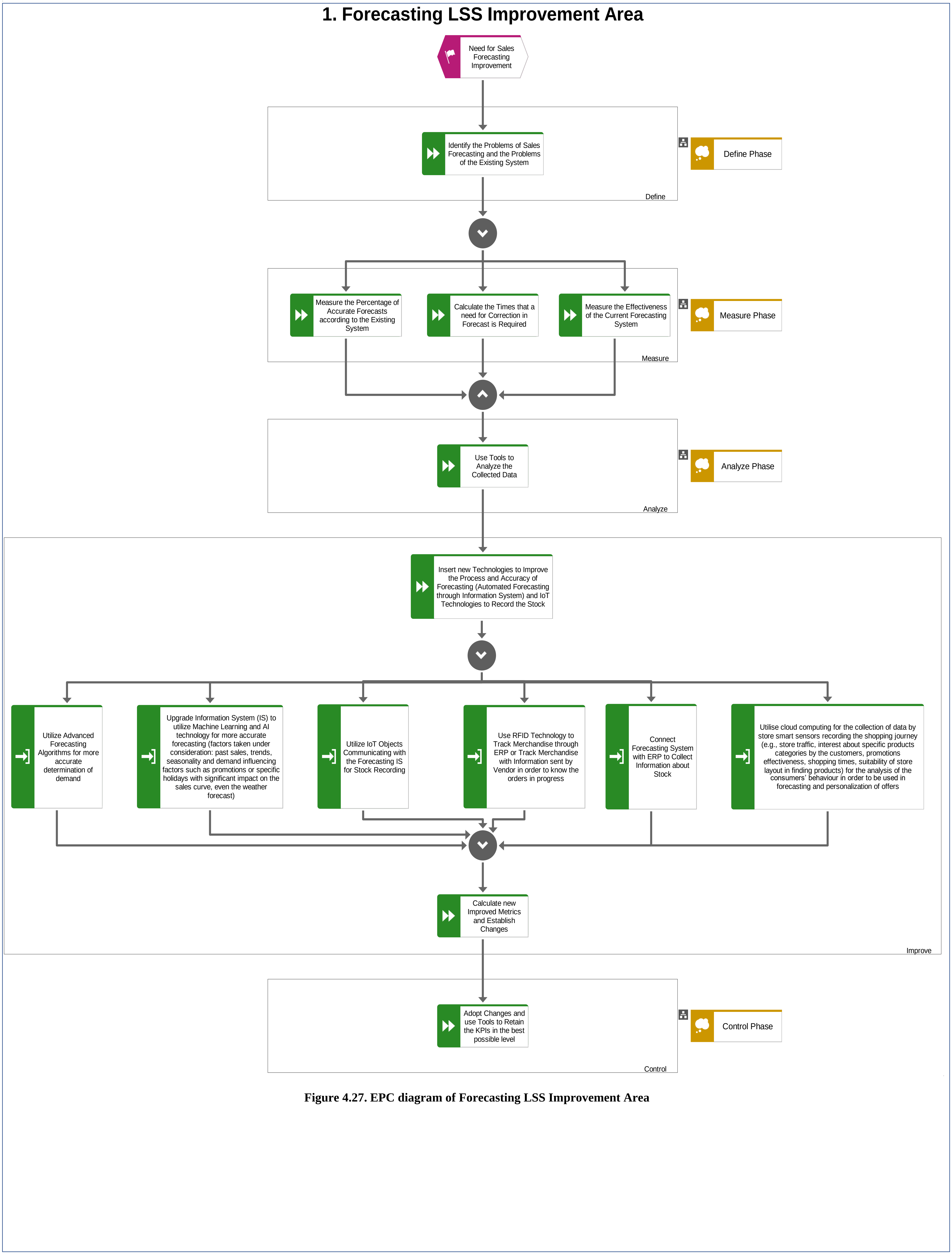


Figure 4.27. EPC diagram of Forecasting LSS Improvement Area

4.4.1.2 Activities connected with this LSS Improvement Area

- 1.1.3. Calculate Sales Forecast
- 5.1.14.14. Send Information for Sales and Stock in Forecasting System
- 5.1.14.17. Save and Elaborate Data of Sales and Stock of Products

4.4.1.3 Description of the DMAIC steps and LSS Initiatives

4.4.1.3.1 Define

The Define phase is the first phase of the LSS project and the aim is the identification of the problems that have been occurred by the sales forecasting method or system that is used right now by the company. The company with utilization of the suitable Define tools according to its needs can identify what are the results of the AS-IS forecasting method or system. Usual problems are stock-outs or excessive stock due to the wrong demand forecasting taking under consideration incorrect or deficient factors of forecasting and incorrect and inconsistent recording of stock.

4.4.1.3.2 Measure

The measure phase encompasses the collection of data that relate to the problems of forecasting method or system identified during the Define phase. A useful metric for the checking of the adequacy of the existing forecasting method or system is the measurement of the percentage of the forecasts that are indeed accurate and do not lead to constant need of recalculation and correction of their results by the Buyers. If this is a problem of the existing forecasting method or system, then the project team should also measure how many times there is a need for correction and recalculation of the forecasts and how much time is spent in this activity. In addition, MAD (Mean Absolute Deviation), which shows how much, on average, the forecasts have deviated from the actual demand, can be used for the measurement and the comparison of different forecasting models (for the same product category for example). MAPE (Mean Absolute Percentage Error) is also a method which works in the same way as MAD, but expresses the forecast error in percentage rather than units in order to be more understandable. Finally, the measurement of the effectiveness of the existing forecasting method or system can be measured by specific KPIs, such as the frequency of stock-outs or excessive stock left in the warehouse for specific SKUs, in specific times of the year. These data should be also collected, because they will facilitate the extraction of inferences in the Analyze phase.

4.4.1.3.3 Analyze

In the Analyze phase, the data that have been collected during the Measure phase are elaborated with the utilization of the appropriate tools, as described in the diagram of tools. The tools that are included in this reference model (e.g., sample t-tests, or ANOVA) have the prerequisite of the data to follow the normal distribution. The normality of the data should be checked and if the data do not follow the normal distribution, it is required to be transformed (e.g., with Box-Cox or Johnson transformation) in order to continue with the analysis. Otherwise, the median-based tools can be used (1 sample sign test, Kruskal-Wallis analysis, Mood’s median test). In the forecasting improvement project, the analysis can start with the Time Series Plots or Bar Charts (both are included in the Charts and Graphs category) in order to identify the forecasting trends and visualize the data collected. FMEA, 5-Whys and Fishbone diagram can categorize and explain the occurring problems and Correlation and Regression Analysis can give insights about the factors affecting the correctness of forecasts under different circumstances (e.g., does seasonality affect the accuracy of forecasts?). 1 or 2 Proportion tests, or Chi-square can be implemented for the analysis of the averages of collected data in order to identify differences in forecasting accuracy by comparing, for example, stock-outs in different products categories and time. 1 or 2 sample t-test or ANOVA can be also utilized for the analysis of raw data (not percentages) of the stock-outs, excessive stocks or sales.

4.4.1.3.4 Improve

The Improvement Actions-LSS Initiatives which are proposed in this reference model for the improvement of forecasting process aim to the increase of accuracy by using contemporary technological solutions. The most important improve action is the upgrading (or the insertion) of Forecasting Information System, utilizing Machine Learning (ML) algorithms in order to take under consideration factors such as past sales, trends, seasonality and demand influencing factors including promotions, specific holidays with significant impact on the sales curve and even the weather forecast. These factors in the passage of time will be adjusted by algorithms, based on the success of the previous forecasts in order to be more accurate. Before this improvement, the company can adopt advanced forecasting algorithms (not ML), like exponential smoothing or algorithms encompassing regression analysis (to find for example the correlation between seasonality and sales) in order to improve the accuracy of the demand and sales calculation. An example of advanced forecasting algorithm is ARIMA, which transforms non-stationary time-series to stationary (differencing), in terms of mean, in order to cope with trend or seasonality (SARIMA). Thus, with the assumption that there is a linear dependence of the time-series of sales, for example, with the past data, the algorithm can predict the future sales. Exponential Smoothing is another forecasting algorithm that can be utilized, which assigns weights to past data that are decaying exponentially when the data gets older. As a result, the biggest weight is given to the more recent data. In contrast to ARIMA, Exponential Smoothing can be used with raw non-static data. The rest LSS initiatives are connected with the insertion of a forecasting system and include the integration of forecasting and ERP system for the collection of data about stock in warehouses and stores, or POs of stores to logistics. This information can be embedded in the forecasting algorithms for the supporting pf the Department of Merchandising for the configuration of the best possible PO to Vendors. The utilization of RFID technology is another improve action that can help in the "live" recording of stock in the warehouse and stores or during the transportation of merchandise from vendor to warehouse. This information recorded in the ERP system can be automatically elaborated by the forecasting system in order to know the exact stock every time, even if the merchandise is on the road. The utilization of IoT sensors that can be put on the shelves of stores, for instance, is an improvement action which can help in the recording of "live" stock and can automatically send the changes in the stock level in the ERP (and, as a result, to the forecasting system), without the need for scanning. Finally, smart sensors can be placed in stores to record the shopping journey of customers e.g., store traffic, interest about specific products categories by the customers, promotions effectiveness, shopping times, suitability of store layout in finding products) for the analysis of the consumers' behaviour in order to be used in forecasting. These data can also be used by the Department of Marketing for the configuration of personalized offers according to consumers' profiles.

The completion of every of the six LSS initiatives should be followed by a re-measurement of the results of the improvements in order to be ascertained that they are effective.

4.4.1.3.5 *Control*

In the Control Phase the aim is the retainment of the improvements and the process inside the limits that have been set. In the case of forecasting, the data which are proposed to be measured are mainly count and attribute. So, the appropriate tools to be used are Laney U charts for the checking of the forecasts accuracy and the fulfillment of the target values (e.g., whether the order quantity is above the forecasted demand). I-MR charts or X Bar-R Charts can be utilized, as well, if the data that should be measured are continuous (raw).

4.4.2 Merchandise Purchasing LSS Initiatives

4.4.2.1 LSS Improvement Area Diagram

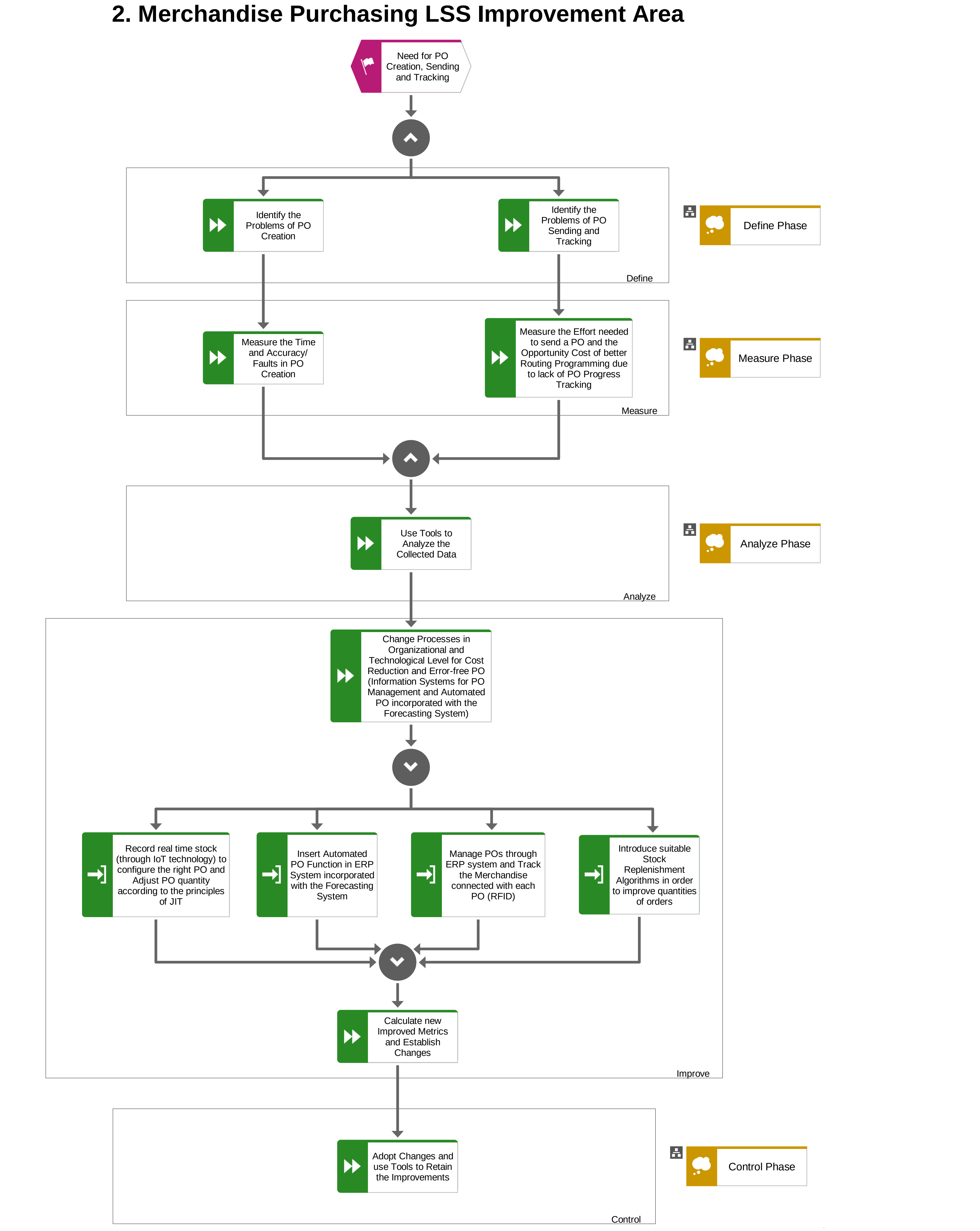


Figure 4.28. EPC diagram of Merchandise Purchasing LSS Improvement Area

4.4.2.2 Activities connected with this LSS Improvement Area

- 1.2.5. Create PO
- 1.2.10. Send PO to Vendor using ERP system
- 1.3.1. Track Order Status
- 5.1.14.14. Send Information for Sales and Stock in Forecasting System
- 5.1.14.18. Propose the Time and Quantity of Replenishment Order according to Analysis of Previous Dates

4.4.2.3 Description of the DMAIC steps and LSS Initiatives

4.4.2.3.1 Define

The aim of this phase is the identification of the problems that have been occurred in Purchase Order (PO) creation, sending and tracking. The company with the utilization of the suitable Define tools, according to its needs, can identify what are the areas of the processes of merchandise purchasing which need to be improved. Usual problems are the inaccurate orders in terms of SKUs and the quantities actually needed, and the delays in sending PO to Vendors, as well as the lack of the adequate tracking of the sent PO resulting in the non-appropriate preparation of the receiving process.

4.4.2.3.2 Measure

The measure phase encompasses the collection of data that relate to the problems of PO creation, sending and tracking, identified during the Define phase. Useful metrics for the comprehension of the AS-IS situation concerning the creation and sending of PO is the measurement of the time and the effort that the Buyers need to prepare and send a PO. The accuracy of the POs can be also measured by calculating the number or the percentage of orders which cover the demand in the best possible level in quantity and type of products. In this phase, the opportunity cost that is a result of the lack of incoming order tracking can be measured, as well, giving a view of how the the routing programming is affected (e.g., a store may not be included in the routing plan of the day due to the lack of knowledge about the time of the incoming orders leaving the store without stock of specific SKUs). This data collection leads to the extraction of inferences in the Analyze phase.

4.4.2.3.3 Analyze

In the merchandise purchasing improvement projects, the analysis can start with histograms or boxplots (both are included in the Charts and Graphs category) in order to visualize the data collected. A Pareto chart, FMEA, 5 Whys or Fishbone diagrams can be utilized for the identification of the most important factors and the faults that lead to the inaccuracy and delays of the POs. Then, Correlation and Regression Analysis can give insights about which of the identified factors indeed affect the configuration of POs. 1 or 2 sample t-test or ANOVA can be also utilized for the analysis of the data (not percentages) concerning the time and effort needed for the creation and sending of POs, as the company may lead to the inference that all the necessary data are not gathered together, and their combination is difficult for the Buyers. In addition, an analysis of the cost effect of the lack of incoming orders tracking in the routing plan could be conducted.

4.4.2.3.4 Improve

The Improvement Actions-LSS Initiatives for the improvement of merchandise purchasing aim to the increase of accuracy, reduction of time and effort and offering incoming orders tracing by using contemporary technological solutions. The three of the four LSS Initiatives concern the facilitation of the creation of PO, as they propose the recording of stock in real time (utilizing IoT technology in shelves) for the determination of the appropriate quality needed to be ordered for each SKU in a timely manner. The time of configuration (and, as a result, the faster sending to Vendor) and the accuracy of POs can be enhanced by the introduction of automated PO function in the ERP system incorporated with the Forecasting system for the utilization of the demand and sales forecasts by the Buyers. This improvement, along with the introduction of stock replenishment algorithms (MRP systems) for the improvement of quantities of orders, can help and reduce the effort of the Buyer in the decision about POs and accelerate the process of PO sending. Finally, the POs are proposed to be managed through the ERP system and RFID technology, which can be used for the tracking of merchandise of each PO that is going to be received. This information can be elaborated through ERP and shared through collaborative platforms managed by Vendors and Retailers.

The completion of every of the four LSS initiatives should be followed by a re-measurement of the results of the improvements in order to be ascertained that they are effective.

4.4.2.3.5 Control

In the case of merchandise purchasing, the data which are proposed to be measured are mainly continuous. So, the appropriate tools for the controlling of the improved processes are I-MR charts or X Bar-R Charts (e.g., control whether the reduction of time in PO preparation and sending is remaining low or the number of correct POs is remaining in the best possible level).

4.4.3 Merchandise Receipt Preparation LSS Initiatives

4.4.3.1 LSS Improvement Area Diagram

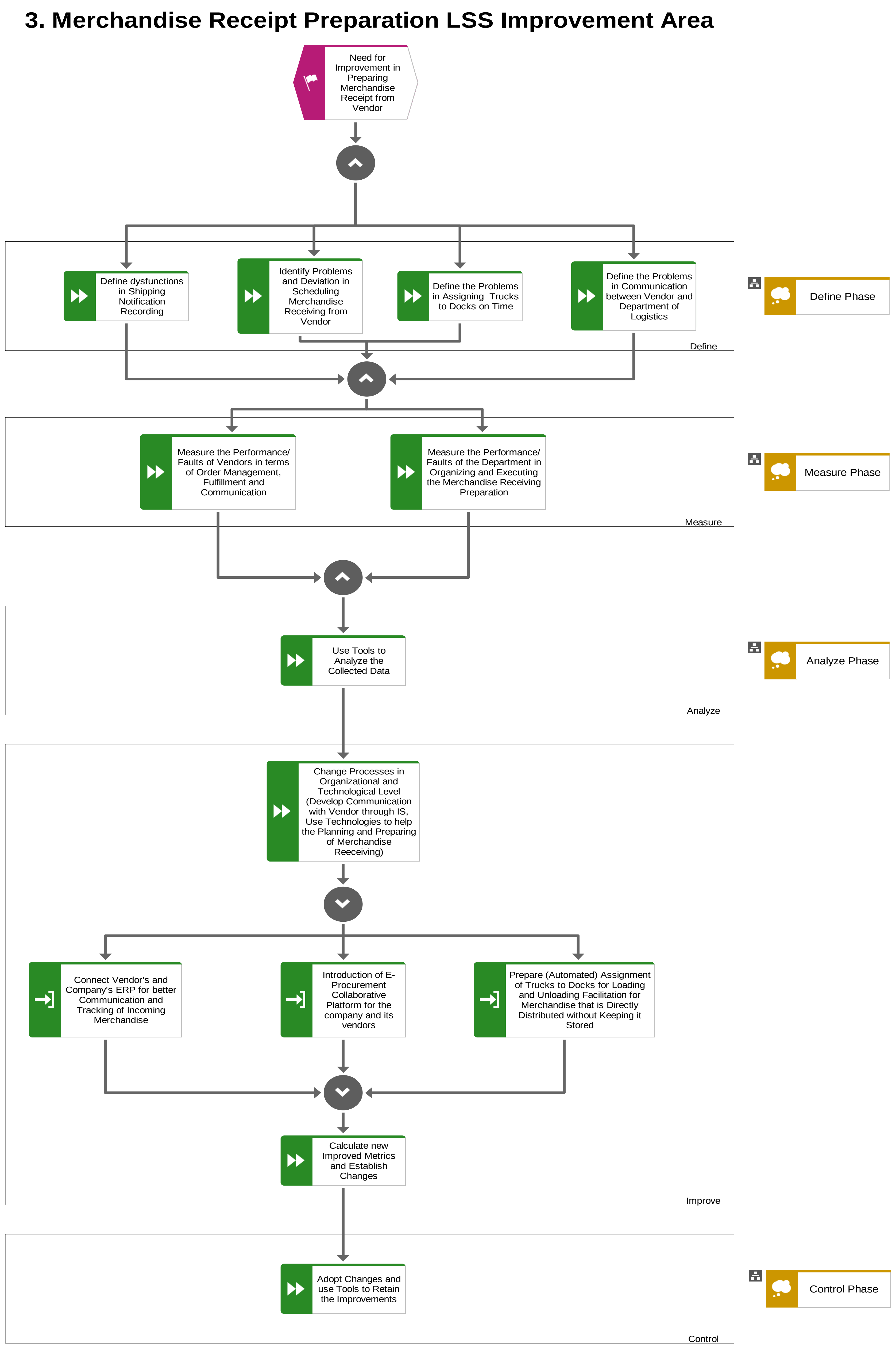


Figure 4.29. EPC diagram of Merchandise Receipt Preparation LSS Improvement Area

4.4.3.2 Activities connected with this LSS Improvement Area

- 2.1.3. (Logistics) Obtain & Record Shipping Notification
- 2.1.5. Schedule Appointment with Vendors/Carriers for Merchandise Receiving
- 2.1.8. Assign Trucks to Docks
- 2.1.28. (Stores) Obtain & Record Shipping Notification
- 2.1.22.8. Assign Docks to Inbound and Outbound Trucks

4.4.3.3 Description of the DMAIC steps and LSS Initiatives

4.4.3.3.1 Define

The Define phase aims to the identification of the problems that have been occurred in the preparation of merchandise receipt. The company with the utilization of the suitable Define tools according to its needs can identify what are the areas of the processes that need to be improved. Usual problems are the dysfunctions in communication with Vendor about the shipping notification and the route of the incoming order, which may lead to difficulties and problems in scheduling the merchandise receipt (day and time), and the pre-assignment of trucks to docks for receipt and then direct distribution (cross-docking).

4.4.3.3.2 Measure

The measure phase encompasses the collection of data that relate to the problems of preparation of merchandise receipt, identified during the Define phase. Useful data for the comprehension of the AS-IS situation, concerning the preparation of merchandise receipt, can be collected by measuring the number of faults due to the lack of the appropriate communication with Vendors about the incoming orders. The faults in orders, sent by Vendors, could be also measured as this information will indicate how Vendors' performance affects the operation and planning of Logistics. Separately, the faults and delays in the execution of the merchandise receipt preparation by the Department of Logistics can be measured in order to conclude whether, for example, the assignment of trucks to docks activity confronts problems. This data collection leads to the extraction of inferences in the Analyze phase.

4.4.3.3.3 Analyze

In the preparation of merchandise receipt improvement projects, the analysis can start with histograms or boxplots (both are included in the Charts and Graphs category) in order to visualize the data collected about delays in merchandise receipt of faults occurring during the process. A Pareto chart, FMEA, 5-Whys or Fishbone diagrams can be utilized for the identification of the most important factors leading to the faults and problems in communication with vendor and in the preparation of merchandise receipt by Logistics. Then, Correlation and Regression Analysis can give insights about which of the identified factors and measured data relate to each other. For example, to what extent the lack of appropriate communication with vendor leads to delays and faults in preparation of merchandise receiving by Logistics, affecting then the distribution process, or how many times the lack of correct information about the incoming orders can lead to problems in assigning the right docks to inbound and outbound trucks for cross-docking. ANOVA can be also utilized for the analysis of the delays and faults occurred in the preparation of merchandise receipt by logistics in order to find out the Vendors that affect the most the process.

4.4.3.3.4 Improve

The Improvement Actions-LSS Initiatives for the improvement of preparation of merchandise receipt aim to the enhancement of collaboration and communication between Logistics and Vendors and as a result the decrease in delays and dysfunctions, the elimination of faults in trucks to docks assignment, by using contemporary technological solutions. Two of the three LSS Initiatives include the connection between Retailer and Vendor through E-procurement collaborative platforms or through the integration of their ERP systems in order to exchange useful information about the incoming orders (e.g., day and time of merchandise receipt, dock of unloading, changes that may needed and should be directly communicated). The third LSS Initiative concerns the introduction of the automated assignment of trucks to docks that could be facilitated and supported by the collaboration of Vendors and Retailer as described in the previous improvement actions.

The completion of every of the three LSS initiatives should be followed by a re-measurement of the results of the improvements in order to be ascertained that they are effective.

4.4.3.3.5 Control

In the case of preparation of merchandise receipt, the data which are proposed to be measured are mainly continuous. So, the appropriate tools for the controlling of the improved processes are I-MR charts or X Bar-R Charts (e.g., control the reduced delays in preparation of merchandise receipt to be in acceptable limits, control the improvement of assigning trucks to docks by measuring the time needed for trucks to find a free dock).

4.4.4 Merchandise Unpacking LSS Initiatives

4.4.4.1 LSS Improvement Area Diagram

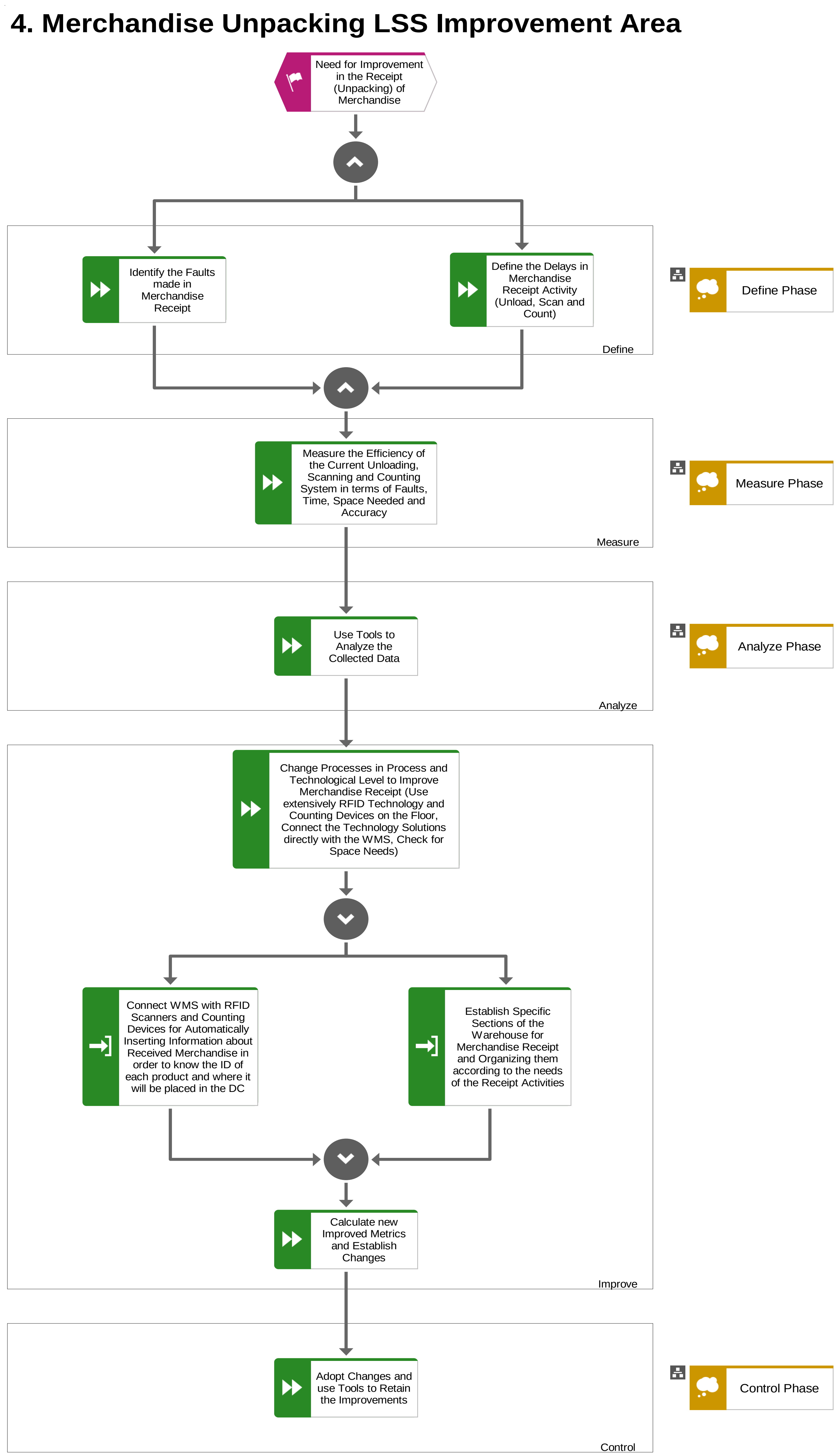


Figure 4.30. EPC diagram of Merchandise Unpacking LSS Improvement Area

4.4.4.2 Activities connected with this LSS Improvement Area

- 2.1.10. Unload, Scan and Count Cartons
- 2.1.22.15. Unload Pallets/ Merchandise

4.4.4.3 Description of the DMAIC steps and LSS Initiatives

4.4.4.3.1 Define

The aim of this phase is the identification of the problems that have been occurred in the merchandise unpacking, including unloading, scanning and counting of products either for storage or for cross-docking. The company with the utilization of the suitable Define tools according to its needs can identify what are the areas of the merchandise unpacking that need to be improved. Usual problems are the delays in the activities of unloading, scanning and counting of merchandise due to the lack of organization in the warehouse and the need to perform manually and multiple times the necessary activities. In addition, faults may occur in the scanning of receipt merchandise because of mixing products and lead to wrong insertion in the WMS.

4.4.4.3.2 Measure

The measure phase encompasses the collection of data related to the problems of merchandise unpacking identified during the Define phase. Useful data for the comprehension of the AS-IS situation concerning the scanning and counting of products can be collected by measuring the time needed for the execution of the scanning and counting activities, how many times faults occur in inserting received merchandise IDs to WMS or how many times there are problems due to the wrong configuration of the DC space where these activities occurring, leading to delays. This data collection leads to the extraction of inferences in the Analyze phase.

4.4.4.3.3 Analyze

In the preparation of merchandise unpacking improvement projects, the analysis can start with histograms or boxplots (both are included in the Charts and Graphs category) in order to visualize the data collected about delays in merchandise unpacking and the time needed for the execution of scanning and counting activities. A Pareto chart, FMEA, 5 Why or Fishbone diagrams can be utilized for the identification of the most important factors leading to these delays (e.g., need to scan all boxes separately, need to manually count the number of boxes/ packages). Then, Correlation and Regression Analysis can give insights about the relationship between different types of faults and delays (e.g., is the number of faults in scanning of incoming merchandise with the RF scanner lead to increase delays, is the time in unpacking causes delays in the cross-docking execution?). An analysis of the performance of the process can be undertaken using 1-sample or 2-sample t-test which can indicate if the average time of merchandise unpacking in different sections of warehouse are not similar in order to infer which section is the faster and should be followed as a guide for the rest sections of warehouse(s), or if the time of unpacking is competitive to world best practices.

4.4.4.3.4 Improve

The Improvement Actions-LSS Initiatives for the improvement of merchandise unpacking are a result of the Analyze phase and aim to the advancement of the process of scanning and counting through technological solutions, and the facilitation of the execution of these activities by reconfiguring the warehouse. The first LSS Initiative that is proposed is the utilization of RFID scanners, connected with the WMS, in the unloading lanes which will accurately and rapidly scan and count the received products for the assignment of the product ID in the WMS and the recording of merchandise moves in the DC in order to facilitate, then, the storage and the cross-docking execution. The establishment of specific sections in the DC for the unloading and unpacking of merchandise configured according to the needs of these activities is the second LSS initiative that is proposed. In these sections, RFID scanners (gates) can be placed on the door in order to immediately scan the products of the received pallets and packages.

The completion of every of the two LSS initiatives should be followed by a re-measurement of the results of the improvements in order to be ascertained that they are effective. Before the investment in new technologies or the establishment of managerial changes, a simulation model of the process can be developed in order to identify whether the metrics are improved. For example, the simulation can reveal if the improved process leads to the reduction of unpacking (unloading, scanning and counting) lead times is achieved up to the desired level.

4.4.4.3.5 Control

In the case of merchandise unpacking, the data which are proposed to be measured are mainly continuous. So, the appropriate tools for the controlling of the improved processes are I-MR charts or X Bar-R Charts (e.g., control the time to maintain the reduction of delays in scanning to be in determined acceptable limits).

4.4.5 Merchandise Storage LSS Initiatives

4.4.5.1 LSS Improvement Area Diagram

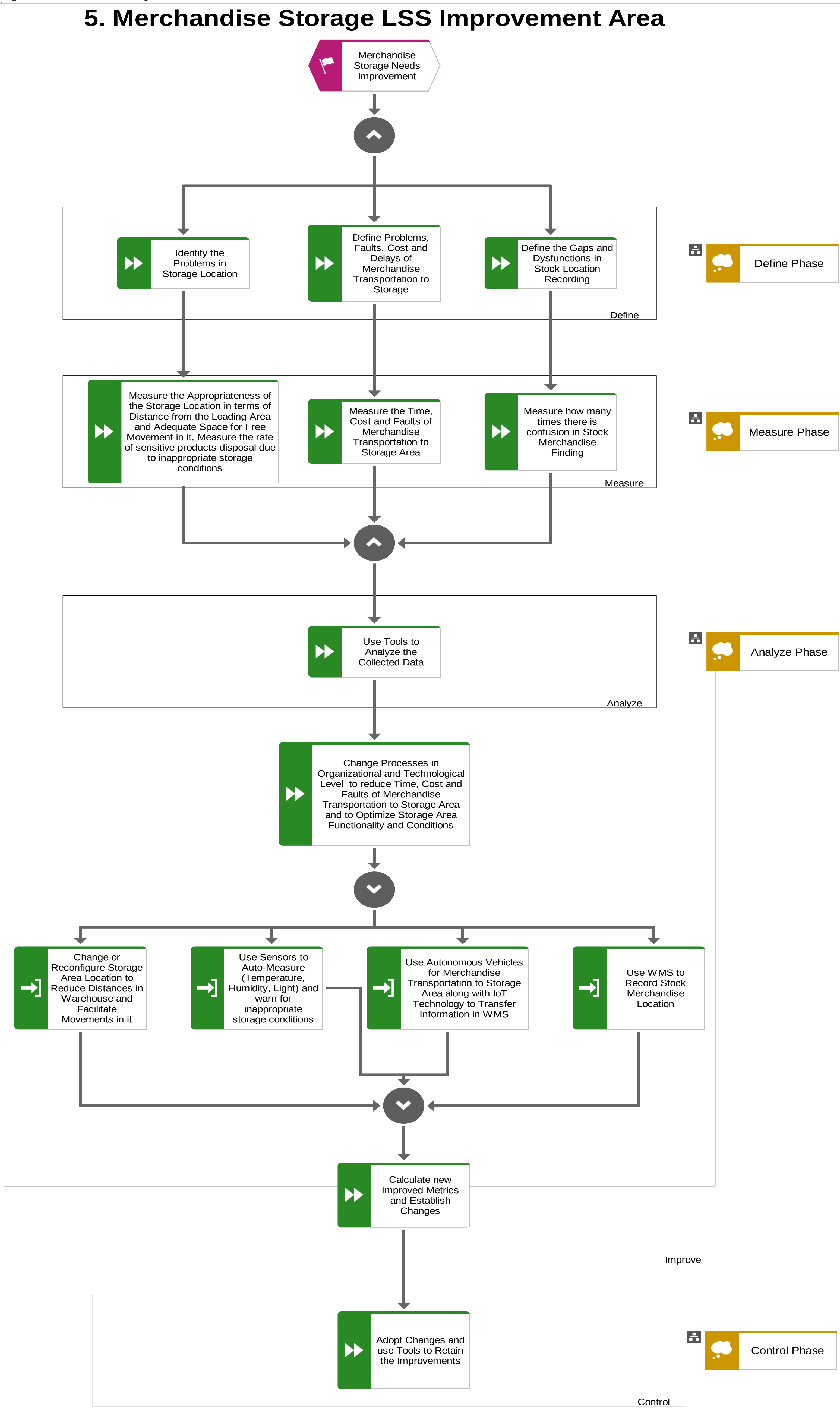


Figure 4.31. EPC diagram of Merchandise Storage LSS Improvement Area

4.4.5.2 Activities connected with this LSS Improvement Area

- 2.1.20. Determine Put-away Location
- 2.1.21. Stage Merchandise for Appropriate Zone-Moves
- 2.1.23. Transport Merchandise to Storage
- 2.1.24. Confirm/Adjust Location
- 2.1.25. Record Stock Location

4.4.5.3 Description of the DMAIC steps and LSS Initiatives

4.4.5.3.1 Define

The Define phase aims to the identification of the problems that have been occurred in the storage of merchandise unpacking. The company with utilization of the suitable Define tools according to its needs can identify what are the areas of the merchandise storage activities which need to be improved. Usual problems are the non-appropriateness of storage location for some products categories which may lead to the disposal of sensitive merchandise increasing loss and the storage of products in locations that afterwards cannot directly be found by the pickers, resulting in the waste of time for searching. Problems concerning delays for merchandise transportation to storage can be also identified or faults, such as the transfer of products to wrong storage area/ slot by the employees.

4.4.5.3.2 Measure

The measure phase encompasses the collection of data related to the problems of merchandise storage identified during the Define phase. Useful data can be collected for the comprehension of the AS-IS situation by the time needed for the transfer of merchandise to storage area from receipt area, and the time needed for searching of products in storage area (and possible delays). The measurement of the number of products that are disposed due to inappropriate conditions of products, as well as the number of times that the merchandise is not in the right position of the storage area are two significant indicators of how well-organized the storage section of the DC is. This data collection leads to the extraction of inferences in the Analyze phase.

4.4.5.3.3 Analyze

In the Analyze phase, the data that have been collected during the Measure phase are elaborated with the utilization of the appropriate tools as described in the diagram of tools. In the merchandise storage improvement projects, the analysis can start with histograms or boxplots (both are included in the Charts and Graphs category) in order to visualize the data collected about the times that have been measured in the Measurement phase. A Pareto chart, FMEA, 5-Whys or Fishbone diagrams can be utilized for the identification of the most important factors affecting the times of transfer to storage area and the difficulties in finding the products that have been stored. Correlation and Regression Analysis can give insights about the relationship between different types of faults and delays (e.g., the relation between the distance of unloading and storage area). An analysis of the performance of the process can be undertaken using 1-sample or 2-sample t-test which can indicate if the average time of merchandise storage in different sections of storage area are not similar in order to infer which section is better organized, and should be followed as a guide for the rest sections of warehouse(s), or if the time needed for storage is competitive to world best practices. This type of analysis can also reveal which section of the storage area contributes to disposals the most.

4.4.5.3.4 Improve

The Improvement Actions-LSS Initiatives for the improvement of merchandise storage are a result of the Analyze phase and aim to the advancement of the activities of transferring merchandise to storage area and recording stock position through technological solutions, and reconfiguration of the warehouse. The two of the four LSS Initiatives, that are proposed, concern the utilization of technological improvements for the transferring of the merchandise from receipt to storage, using contemporary human-driven electric vehicles (e.g., forklifts with embedded RF or RFID scanners) or autonomous vehicles (robots), which can be guided and move in the warehouse by communicating with each other through IoT sensors and through the guidance of WMS, and the recording of the stock location. The autonomous vehicles can spot the location of products in order to be easily accessible afterwards. This location can be also recorded in the WMS in order to be apparent anytime to warehouse employees. In addition, an LSS initiative for the reduction of disposed products is proposed by adding sensors for the auto-measurement of temperature, humidity and light in order to warn the employees for inappropriate storage conditions of the sensitive products and lead to corrective actions. Finally, an improvement of the configuration of the storage area and DC layouts is proposed for the reduction of the distances (and as a result the time) needed for the transfer of merchandise and for the facilitation of the moves of autonomous (or human-driven) vehicles.

The completion of every of the four LSS initiatives should be followed by a re-measurement of the results of the improvements in order to be ascertained that they are effective. Before the investment in new technologies or the establishment of managerial changes, a simulation model of the process can be developed in order to identify whether the metrics are improved. In the case of merchandise storage, the reduction of time needed for storing and searching of products, which is translated to labour cost reduction, can be checked after the reconfiguration of the warehouse or the insertion of technological solutions for the recording of products location.

4.4.5.3.5 Control

In the case of merchandise storage, the data which are proposed to be measured are mainly continuous. So, the appropriate tools for the controlling of the improved processes are I-MR charts or X Bar-R Charts (e.g., control the time needed for the transfer of merchandise from the unloading area to the storage area). Laney P charts can be utilized to control the percentage of products disposal to be in specific pre-determined limits.

4.4.6 Cross-Docking Utilisation LSS Initiatives

4.4.6.1 LSS Improvement Area Diagram

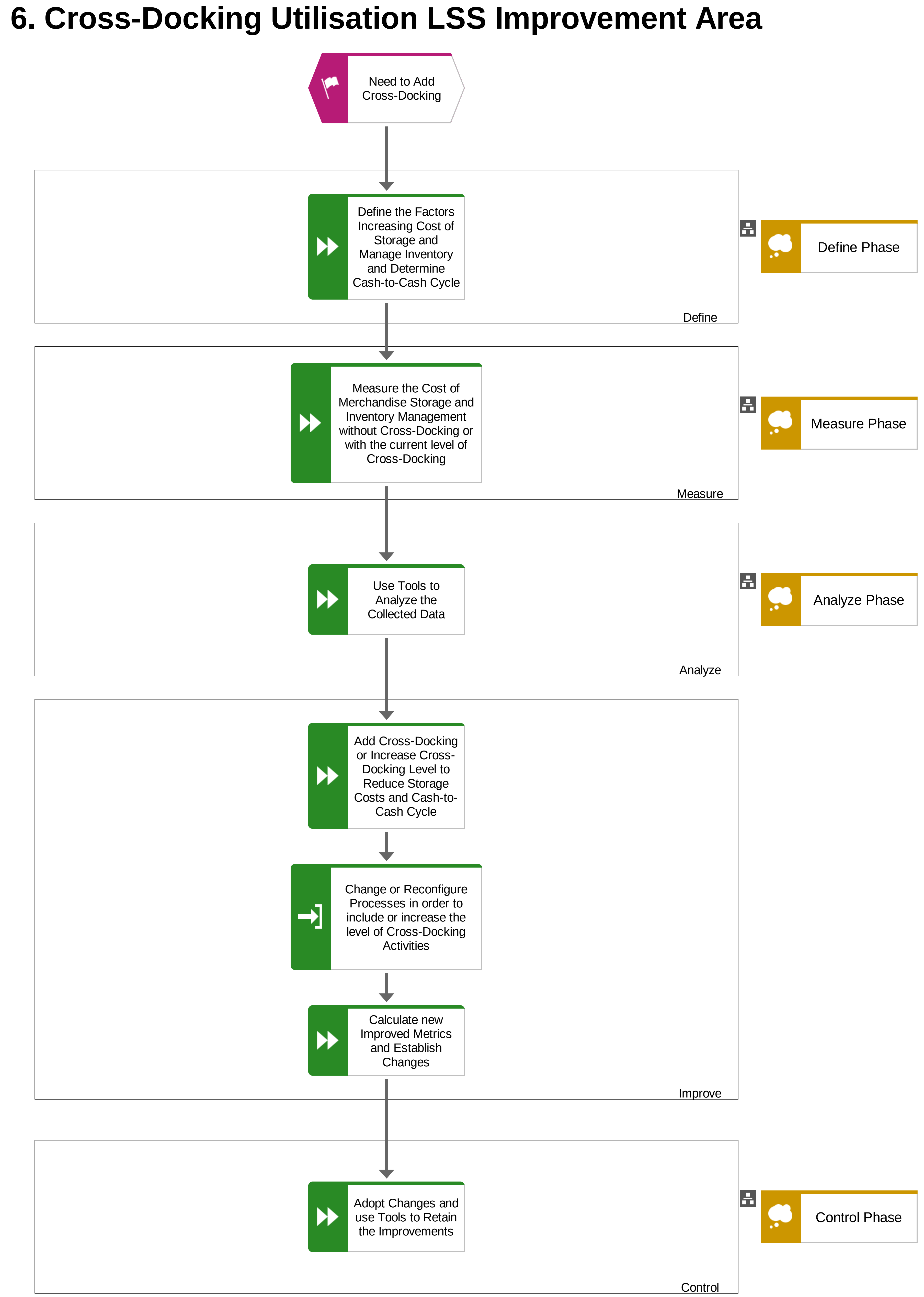


Figure 4.32. EPC diagram of Cross-Docking Utilisation LSS Improvement Area

4.4.6.2 Activities connected with this LSS Improvement Area

- 2.1.22. Flow-through Cross-dock Merchandise

4.4.6.3 Description of the DMAIC steps and LSS Initiatives

4.4.6.3.1 Define

This phase aims to the identification of the need for adding cross-docking in the operation of the supply chain. The company with the utilization of the suitable Define tools according to its needs can identify the factors that increase the cost of storage and inventory management, such as the stock maintenance and more moves than needed for the merchandise to be stored (e.g., moves due to lack of space in warehouse sections, or among warehouses). The factors extending cash-to-cash cycle can be also determined, like the retainment of excessive stock that is not needed (that may be in different warehouses).

4.4.6.3.2 Measure

The measure phase encompasses the collection of data related to the problems of merchandise storage identified during the Define phase. Useful data can be collected for the comprehension of the AS-IS situation. The most important measurement of this improvement project is the cost of merchandise storage and inventory management, which can be defined by the data of the company without the insertion of cross-docking or with a low level of cross-docking in its operations. The number of receipts of specific product categories by specific Vendors that contribute to the main volume of products that are sold can also be measured. This data collection leads to the extraction of inferences in the Analyze phase.

4.4.6.3.3 Analyze

For the decision of the introduction of cross-docking, it is important to visualize the data of merchandise storage cost collected in Measure phase with any type of plot that is convenient (e.g., time series plot of storage cost per month per Vendor per product category) in order to infer whether the cross-docking could help in its reduction. A Pareto chart can be utilized to visualize the percentage of products (and their value) that contribute the most to the receipt of merchandise by Logistics and the delivery of merchandise to Stores. A Correlation and Regression Analysis can also be conducted in order to find how strong is the relationship between the cost of the storage and the movements in warehouse, and the products that are mainly received and distributed or have high value.

4.4.6.3.4 Improve

The Improvement Actions-LSS Initiatives which are proposed are a result of the Analyze phase and aim to the investigation on whether cross-docking activities can be introduced. Cross-docking helps in the decrease of storage cost owing to its benefit of the elimination of stocks. The company should choose between full cross-docking or cross-docking along with a safety stock of the selected products. The second is better for retailers introducing cross-docking for first time in their operations. A selection of merchandise that is suitable for cross-docking is also crucial for the adjustment of the needs of the company with the flow of the process. The company should choose categories of products according to specific factors, such as the life cycle of product, the space that it needs in the storage area and on the shelf of the store and the shelf life-cycle. For the support of the cross-docking movements and activities the warehouse should be reconfigured to have the most appropriate shape (e.g., L-shape, T-shape, U-shape, H-shape)

The completion of this LSS initiative should be followed by a re-measurement of the results of the improvements in order to be ascertained that they are effective.

4.4.6.3.5 Control

In the case of the decision for cross-docking adding, the data of costs should be controlled to be in the limits that the company has set. The categories of products and the percentage of cross-docking can change to meet cost target.

4.4.7 Cross-Docking Execution LSS Initiatives

4.4.7.1 LSS Improvement Area Diagram

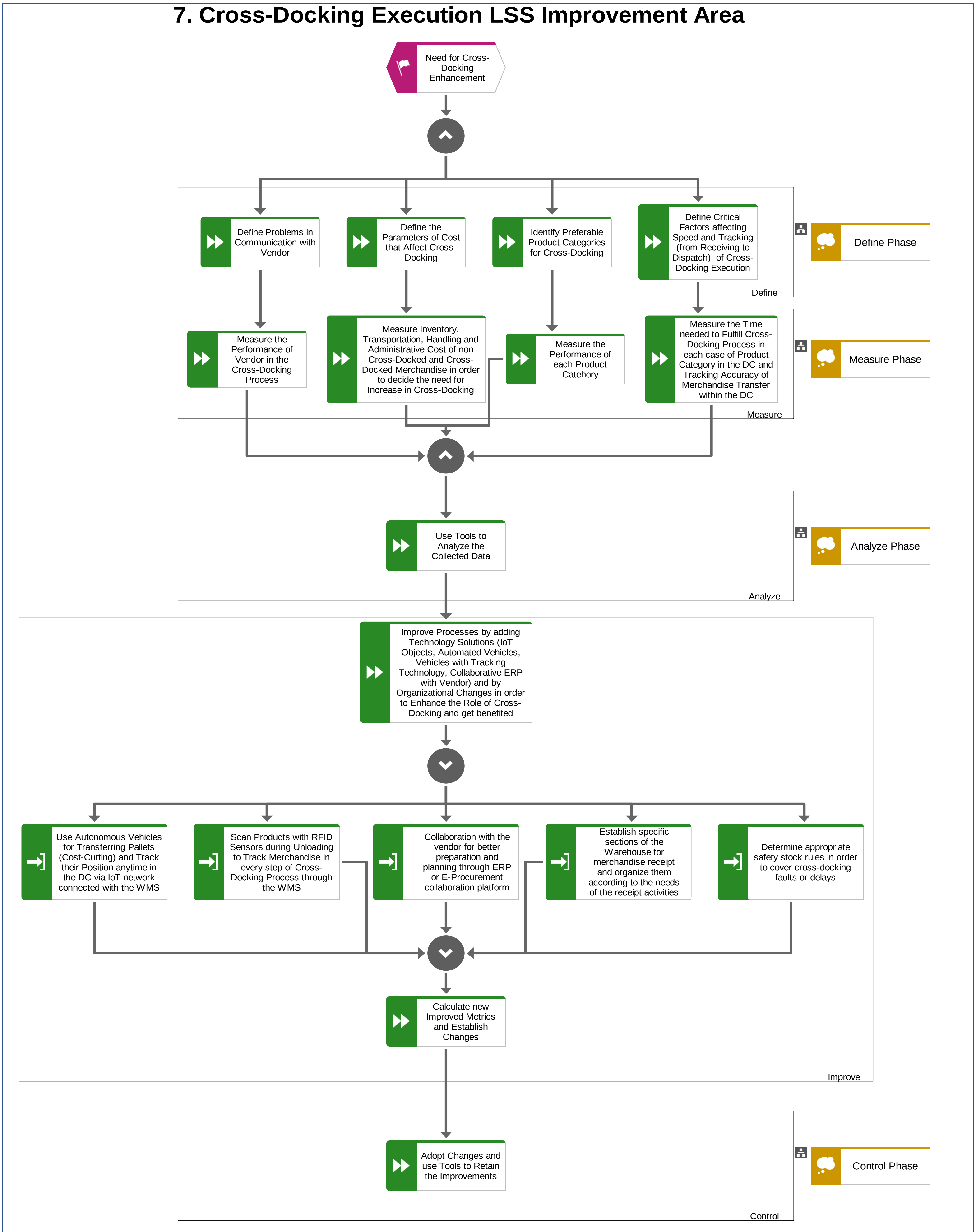


Figure 4.33. EPC diagram of Cross-Docking Execution LSS Improvement Area

4.4.7.2 Activities connected with this LSS Improvement Area

- 2.1.22. Flow-through Cross-dock Merchandise
- 2.1.22.5. Check and Adjust Order Delivery Details along with the Vendor
- 2.1.22.15. Unload Pallets/ Merchandise
- 2.1.22.18. Track the Route of the Pallets/ Merchandise from Receiving to Dispatch

4.4.7.3 Description of the DMAIC steps and LSS Initiatives

4.4.7.3.1 Define

This phase aims to the identification of the problems that have been detected and affect the smooth cross-docking execution. The company with the utilization of the suitable Define tools according to its needs can identify what are the areas of the cross-docking execution activities which need to be improved. Usual faults can be identified in the communication with Vendor that may be problematic and deficient resulting in the lack of the necessary synchronization for the low of the cross-docked merchandise. There may occur problems due to the selection of wrong products for cross-docking, so the preferable categories of merchandise for cross-docking need to be redetermined. In addition, in this phase the factors that affect the speed and tracking of cross-docking process can be defined (e.g., the non-existence of a specific area in the warehouse or the configuration of the warehouse in order to facilitate cross-docking, the non-existence of technological equipment for the recording in real time the place of products in the DC). Finally, the cost parameters (transportation, handling, inventory, and administrative cost) connected with and affected by cross-docking could be defined in order to be calculated.

4.4.7.3.2 Measure

The measure phase encompasses the collection of data related to the problems of cross-docking execution identified during the Define phase. Useful data can be collected for the comprehension of the as-is situation starting from the measurement of the performance of Vendors concerning their communication and fulfillment of merchandise delivery according to the schedule without delaying the rest of the process. The performance of each product category that was decided to be distributed through cross-docking can be measured in terms of movements and sales. This measurement incorporated with the measurement of the cost categories described in the Define phase, which are suggested to be measured, can reveal useful insights, in the Analyze phase, about the suitability of the selected products categories for cross-docking. Another measurement which reveals the efficiency of cross-docking and the suitability of the selected product categories is the time of cross-docking fulfillment for each product category. The accuracy of the tracking of merchandise during the process can be calculated by measuring the number or the percentage of movements that are recorded in every step of cross-docking and identify the number or percentage of movements missing.

4.4.7.3.3 Analyze

In the cross-docking execution improvement projects, the analysis can start with histograms or boxplots (both are included in the Charts and Graphs category) in order to visualize the data collected in the Measurement phase about the delays because of lack of efficient communication and deficient performance of Vendors or of the not appropriate tracking of merchandise throughout cross-docking steps. Pareto charts, FMEA, 5-Whys or Fishbone diagrams can be utilized for the identification of the most important factors affecting the cost categories and how these factors relate to the cross-docking process, the improvement of which can lead to cost reduction (e.g., the inventory cost is affected by the stock which cross-docking decreases, the handling cost may be higher if the merchandise should be transferred to storage area and then again in loading area). Correlation and Regression Analysis can give insights about the degree of relation between the performance of Vendor and the smooth flow of cross-docking. It can also show whether the product categories that have been selected for cross-docking have positive impact to the cost (e.g., check independently each product category to find out if its contribution to the overall cost reduction is strong) An analysis of the performance of the different products categories in cross-docking can be undertaken using 1-sample t-test, 2-sample t-test, or ANOVA (or Chi-Square for percentages) which can indicate if the average time or average movements of merchandise are worth considering for the decision of change product categories for cross-docking. An analysis using the same tools can also reveals which section or warehouse in which cross-docking is executed is the more efficient and can be followed as a guide for the configuration of the others.

4.4.7.3.4 Improve

The Improvement Actions-LSS Initiatives for the improvement of cross-docking execution are a result of the Analyze phase and aim to the advancement of the activities through technological solutions, and reconfiguration of the warehouse. Five LSS Initiatives are suggested in total. The utilization of RFID technology in order to track the position of merchandise in every step of cross-docking, from unloading to loading to trucks again, is the first technological solution that is proposed aiming to the control of movements of products in the warehouse. The second improvement is more contemporary and focuses not only on the tracking of merchandise and the steps of cross-docking, but also in its execution by autonomous vehicles connected with the WMS through an IoT network which can lead to the reduction of more than one parameters of costs (administrative and handling). The communication and collaboration with Vendors can be enhanced through the interconnection of company's and vendors' ERP system or the establishment of E-Procurement collaboration platforms which can offer a better planning of cross-docking activities for the avoidance of delays and the faster execution of the process. Furthermore, specific sections and lanes of the warehouse should be established and configured (after the decision of the shape of warehouse as described in *6. LSS Cross-Docking Adding Improvement Area*) according to the needs of cross-docking and will be dedicated for the unloading, temporary storage, picking/ packing and loading of cross-docked products in order to not be confused with the operation of the rest of the DC. Finally, according to the analysis conducted in the previous phase the company should regularly check, decide and redetermine the product categories which are appropriate for cross-docking. The determination of a safety stock rule for concrete product categories coming from specific Vendors, whose performance is not the expected one, but their products are considerably suitable for cross-docking, will be also useful as an action for the mitigation of risk of those Vendors' deliveries delays and discrepancies.

The completion of every of the five LSS initiatives should be followed by a re-measurement of the results of the improvements in order to be ascertained that they are effective. Before the investment in new technologies or the establishment of managerial changes, a simulation model of the process can be developed in order to identify whether the metrics are improved. In cross-docking execution, for example, the elimination of delays via the cross-docking lead time reduction is crucial. For this reason, after the warehouse reconfiguration for the better supporting of cross-docking process or the changing of product categories involved in cross-docking, or the introduction of technological solutions (for the scanning, for the cross-transferring of merchandise into the DC, and for the better collaboration with Vendors) an estimation of the cross-docking lead time reduction (and as a result of the cost reduction) can be conducted through simulation.

4.4.7.3.5 Control

In the case of cross-docking execution, the data, which are proposed to be measured, are mainly continuous. So, the appropriate tools for the controlling of the improved processes are I-MR charts or X Bar-R Charts (e.g., control the number of movements and the distances that the warehouse vehicles travel in the DC in order to find out whether the configuration of warehouse can maintain them as low as possible, control the cost reduction, control the time of the process fulfillment).

4.4.8 Placing of Stores' Orders LSS Initiatives

4.4.8.1 LSS Improvement Area Diagram

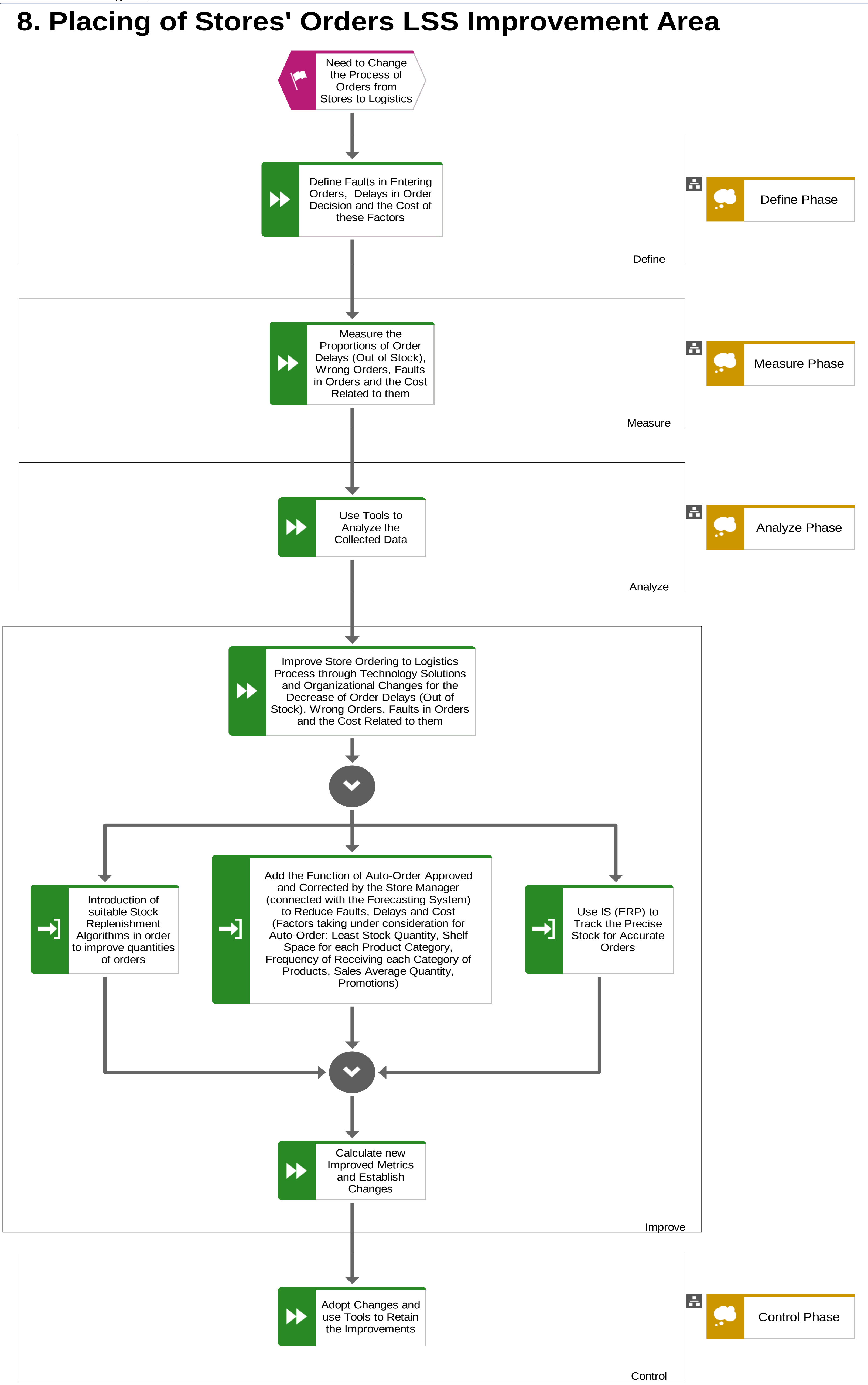


Figure 4.34. EPC diagram of Placing of Stores' Orders LSS Improvement Area

4.4.8.2 Activities connected with this LSS Improvement Area

- 3.1.1.7. Enter Order to the System
- 5.1.14.12. Record Stock Remaining by Sales

4.4.8.3 Description of the DMAIC steps and LSS Initiatives

4.4.8.3.1 Define
This phase aims to the identification of the problems that affect placing of stores' orders according to their replenishment needs. The company with the utilization of the suitable Define tools based on its needs can identify what are the areas of the placing of orders by stores which need to be improved. Usual problems occurring in the placing of orders by stores is the wrong quantity of products included in the order which may lead to stock-outs or deficient replenishment, or excessive stock of products categories, that were not needed to be ordered in high quantities. Another problem is the wrong time or delays in the placing of order which again can lead to stock-outs or deficient replenishment leaving empty shelfs, lowering the service level and resulting in loss of earnings.

4.4.8.3.2 Measure
The Measure phase encompasses the collection of data related to the problems of the placing of stores' orders identified during the Define phase. Useful data can be collected for the comprehension of the AS-IS situation starting from the number of stock-outs that the store had to confront in a long period of time and the percentage or the number of wrong orders. The delays of orders placing (exceeding the order windows of stores to logistics) is also an important metric which can show how quickly the Store Manager is able to collect the necessary data regarding the stock of products to place the order. In addition, a measurement of the deviation between the needed quantities of each product category for replenishment and the actual order quantity should be conducted. This can be occur through the measurement of stock-outs (loss of earnings) or excessive stock (high cost) in stores due to the imprecise calculation of the order quantity, because of lack of necessary stock or demand data. In this way, the number of orders that are "wrong" in terms of quantity and time of placement can be detected and the calculation of loss of earnings can be conducted.

4.4.8.3.3 Analyze
In the placement of stores' orders improvement projects, the analysis can start with histograms or stacked bar charts (both are included in the Charts and Graphs category) in order to visualize the data collected in the Measurement phase about the frequency of inaccurate orders quantity or orders delayed placement per product category, or the percentage of wrong orders, respectively. Pareto charts, 5-Whys or Fishbone diagrams can be utilized for the identification of the most important factors affecting the placement of appropriate orders (e.g., non-availability or delay in the collection of all the appropriate data to place the order, lack of knowledge about the exact stock of the store for each product category in a timely manner). Correlation and Regression Analysis can give insights about if quantity or delays lead to the most inaccurate orders. The strongness of correlation between loss of earnings and wrong orders can be studied, as well. An analysis of the 1-sample t-test, 2-sample t-test (or proportion tests), or ANOVA (or Chi-Square for percentages) can elaborate the differences of the average stock-outs occurring among several product of categories which are included in orders. This kind of analysis can also reveal how significant is the loss of earnings of different product categories which are not properly ordered.

4.4.8.3.4 Improve
The Improvement Actions-LSS Initiatives for the improvement of placing of stores' orders are a result of the Analyze phase and aim to the advancement of the activities through technological solutions. Three LSS initiatives are suggested in total, starting from the introduction of suitable stock replenishment algorithms in order to improve the quantities of orders to avoid stock-outs and excessive stocks in the back-stock of stores. The data which can be used in these algorithms are sales daily run rate, supplier lead time, days coverage, existing stock in store, on order stock and stock in transit. The upgrade of ERP functionality, in collaboration with the appropriate IoT sensors for the real-time and direct recording of stock in store

is proposed as an improvement action in order to provide the algorithm with the necessary data and at the same time to inform the Store Manager precisely and immediately about the stock. A further improvement of the algorithmic replenishment is the adding of the function of auto-order which will generate the suitable order taking under consideration specific information and data gathered from the Forecasting system in order to reduce faults (e.g., of quantities) in orders, delays and the cost that these factors are involved in. The factors that can be taken under consideration for auto-order is the least stock quantity, shelf space for each product category, frequency of receiving each product category, sales average quantity, and promotions. The auto-generated order can be checked by the Store Manager who should also approve it or alter it when needed due to exceptional situations.

The completion of every of the five LSS initiatives should be followed by a re-measurement of the results of the improvements in order to be ascertained that they are effective.

4.4.8.3.5 *Control*

In the case of orders placing by stores, the data which are proposed to be measured are continuous or percentages. So, for the controlling of the improved processes both I-MR charts or X Bar-R Charts (e.g., control the number of times that the store places the order in its order window) and Laney P charts can be utilized. (e.g., control the percentage of the products stock-outs due to imprecise order quantity).

4.4.9 Back-Hauling LSS Initiatives

4.4.9.1 LSS Improvement Area Diagram

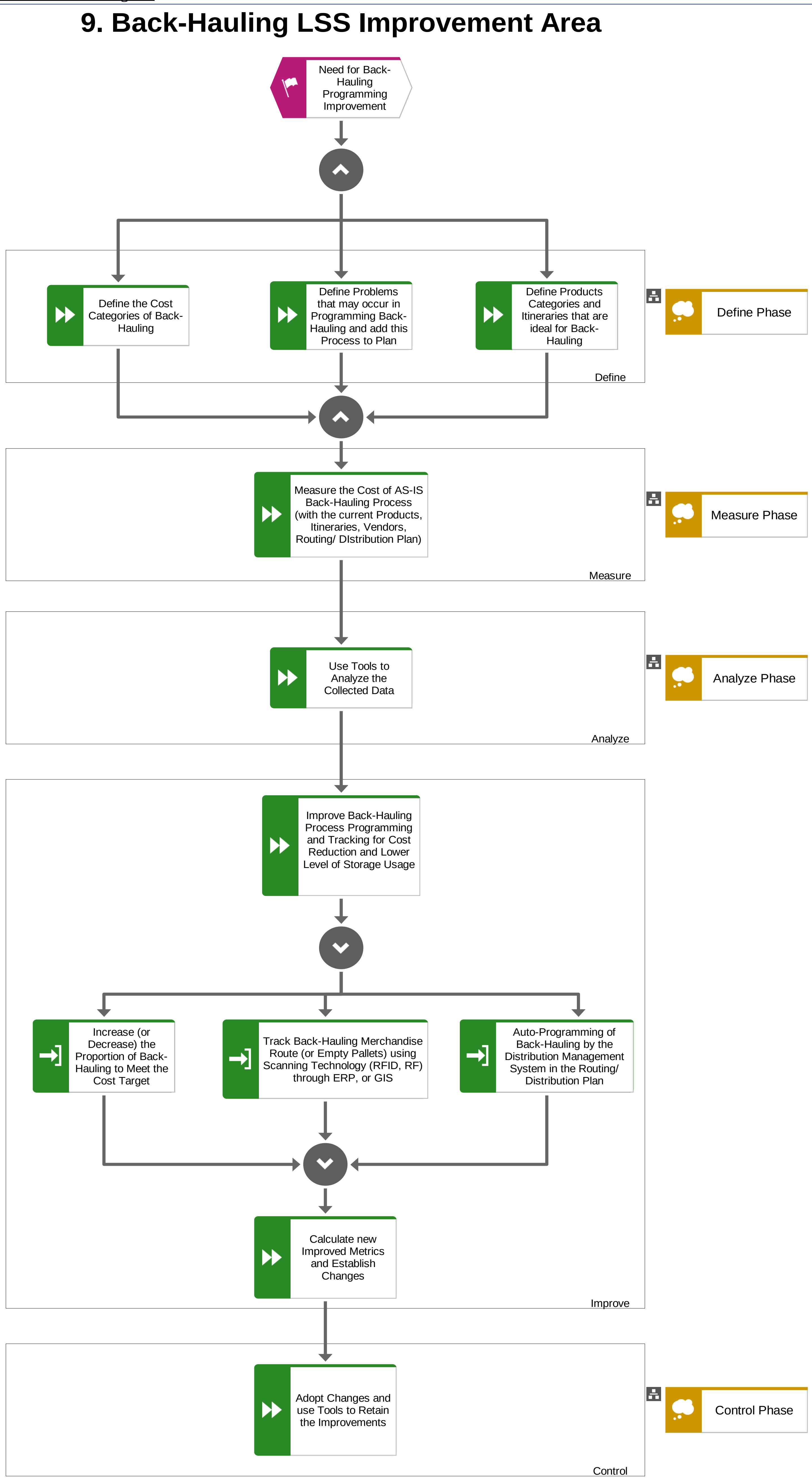


Figure 4.35. EPC diagram of Back-Hauling LSS Improvement Area

4.4.9.2 Activities connected with this LSS Improvement Area

- 3.1.2.6. Plan Back-Hauling and Empty Pallets Returning

4.4.9.3 Description of the DMAIC steps and LSS Initiatives

4.4.9.3.1 Define

The Define phase aims to the identification of the problems and the factors affecting the back-hauling planning. The company with the utilization of the suitable Define tools, based on its needs, can identify what are the areas of the back-hauling planning which need to be improved. Usual problems affecting this process are the non-appropriate programming of back-hauling in terms of the right itineraries or the right products, or Vendors to be chosen. This can lead to the increase of the transportation cost instead of reduction, as the trucks may cover bigger distances. Another problem that may occurs is the excessive back-hauling itineraries due to commercial contracts with Vendors, for lower cost of products, which may result in higher administrative and transportation cost outweighing the benefit of lower acquisition cost. Finally, the selection of specific routes which keep the transportation cost as low as possible may not be followed by the trucks.

4.4.9.3.2 Measure

The Measure phase encompasses the collection of data related to the problems back-hauling planning identified during the Define phase. The most important problem is the increase of the transportation cost. For this reason, the cost of the AS-IS back-hauling process should be measured in this phase in order to find out whether the already established contracts, itineraries, products, vendors and routing plans come in accordance with the target of the company for the cost. The most significant metric that affects the back-hauling cost is the distances of the routes that the trucks should follow, the measurement of which can give useful insights about the efficiency of the current state of back-hauling.

4.4.9.3.3 Analyze

In the back-hauling improvement projects, the analysis can start with histograms or box-plots charts (both are included in the Charts and Graphs category) in order to visualize the data collected in the Measurement phase about the distances that the trucks travel in different itineraries or from different Vendors. A 5-Whys analysis can be utilized for the identification of the most important factor affecting the need for covering long distances (e.g., too much amount of merchandise is received through back-hauling, the plan of back-hauling needs improvement). Correlation and Regression Analysis can give insights about how crucial the effect of the itineraries, product categories, and routing plan are to the back-hauling cost. An analysis of the 1-sample t-test, 2-sample t-test, or ANOVA can give useful inferences by comparing the efficiency of the existing back-hauling itineraries and routing plan in order to understand the contribution of the different distances to the overall cost.

4.4.9.3.4 Improve

The Improvement Actions-LSS Initiatives for the improvement of back-hauling are a result of the Analyze phase and aim to the advancement of the activities through technological solutions or differentiations in the process. Three LSS initiatives are suggested in total, starting from the decision of the increase or decrease the back-hauling merchandise in order to meet the cost target that the company has set for back-hauling transportation and management. The reduction of cost can also be achieved by the introduction of algorithms which auto-program (planning) back-hauling according to the needs of the company and can be inserted in the routing plan of the company (VRB-vehicle routing with backhauls) proposing at the same time the routes that should be followed for covering smaller distances and reducing the carbon footprint of trucks, which may be a sustainability goal of the company. The back-hauling plan can be incorporated with the distribution plan through the DMS. Moreover, the proposal of the tracking of back-hauling merchandise route (or empty pallets returning) through ERP using RFID (or RF) technology or through a GIS (Geographical Information System) system can give the overview of the process during its execution and the ability to check whether the trucks are following the predetermined route or to know the exact quantity of incoming merchandise (or empty pallets) for the organization of the storage area or the planning of cross-docking before the arrival of merchandise to the warehouse.

The completion of every of the five LSS initiatives should be followed by a re-measurement of the results of the improvements in order to be ascertained that they are effective.

4.4.9.3.5 *Control*

In the case of back-hauling, the data which are proposed to be measured are continuous. So, for the controlling of the improved processes I-MR charts to monitor the back-hauling cost to be as low as possible in order to decide which vendors, product categories, or itineraries to keep for back-hauling, and X Bar-R Charts to monitor that the distances (in km) covered by trucks are under the determined upper limit can be used.

4.4.10 Picking/Packing LSS Initiatives

4.4.10.1 LSS Improvement Area Diagram

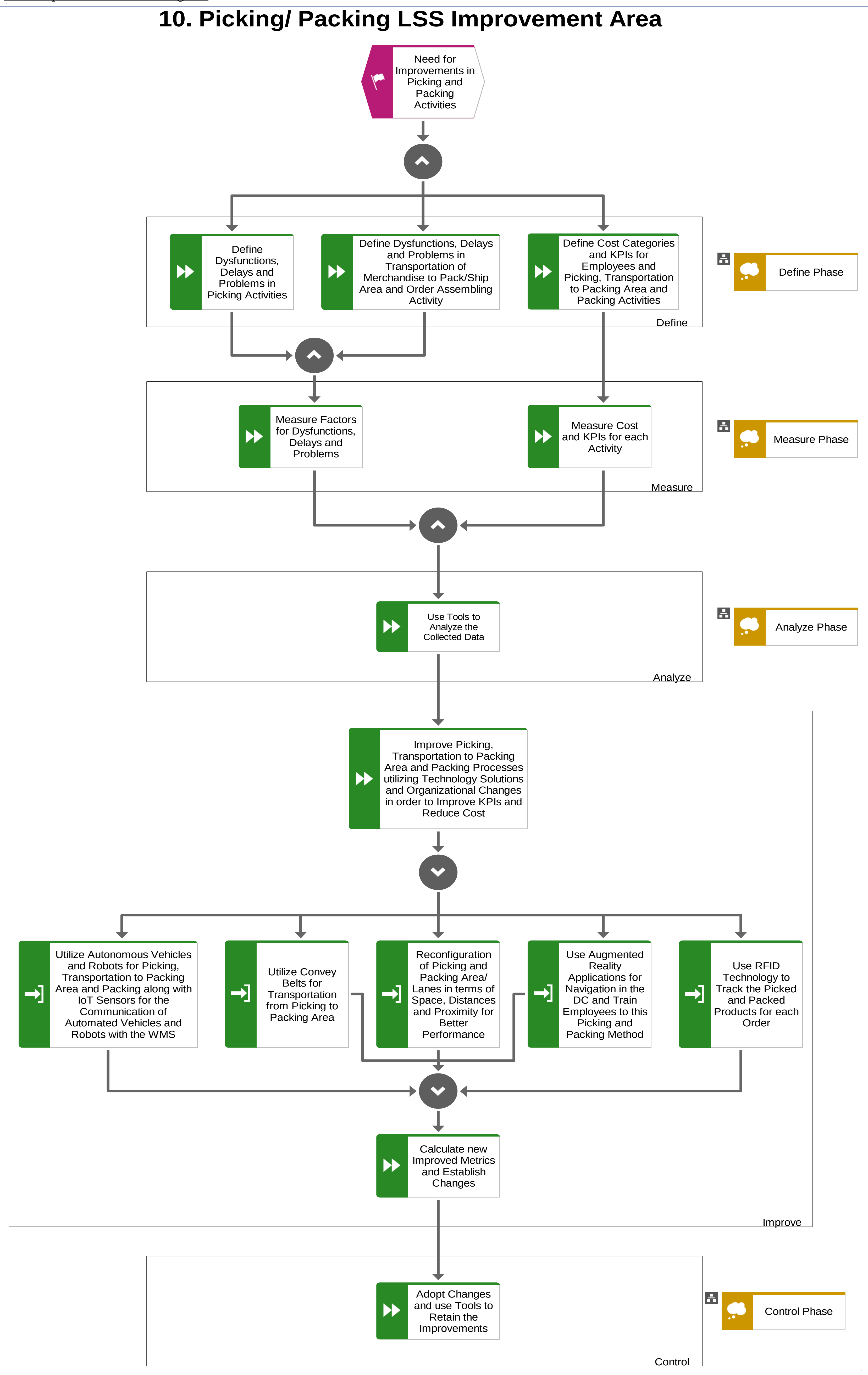


Figure 4.36. EPC diagram of Picking/Packing LSS Improvement Area

4.4.10.2 Activities connected with this LSS Improvement Area

- 3.1.12. Pick Products
- 3.1.15. Transport Merchandise to Pack/Ship Area
- 3.1.16. Assemble Order into Shipping Container/ Pallet

4.4.10.3 Description of the DMAIC steps and LSS Initiatives

4.4.10.3.1 Define

The Define phase aims to the identification of the problems and the factors affecting the picking/packing process. The company with the utilization of the suitable Define tools based on its needs can identify what are the areas of the picking/picking activities which need to be improved. Usual problems affecting these activities are the delays of picking/packing and the transportation of stored products to picking area, due to the confusing configuration of the warehouse, the picking/packing of wrong products, because of the lack of the appropriate guidance, and the lack of prioritization in picking products. In addition, problems and delays occurring due to the reduced performance of the pickers can be identified by introducing the KPIs of pickers' performance. The cost categories of picking/packing process can be also identified in order to decide which of them can be reduced (e.g., labor cost and administrative cost).

4.4.10.3.2 Measure

Data can be collected for the time that is needed for pickers to execute picking and packing activities for different type of products or in different warehouse sections. This measurement can come in accordance with the measurement of the KPIs of the pickers' performance and the delays that may occur, due to the problems described in the Define phase. In addition, the faults in picking/packing activities (e.g., wrong products) can be recorded, as they lead to the increase of cost. In the Measure phase the cost of picking/packing process should be measured in order to find out the factors that affect it in the Analyze phase. Another metric that can be measured is the labor and equipment utilization for picking/packing execution (in time or percentage), as it can reveal the productivity of the AS-IS process.

4.4.10.3.3 Analyze

In the picking/packing improvement projects, the analysis can start with histograms or box-plots charts (both are included in the Charts and Graphs category) in order to visualize the data collected in the Measurement phase about the time that is needed for the picking/packing of different product categories or in different section of the warehouse. In this way the detection of delays and performance fluctuations can be detected. A 5-Whys analysis or a Fishbone diagram can be utilized for the identification of the most important factors affecting the delays on picking/packing, the picking of wrong products, and the performance of pickers. Correlation and Regression Analysis can reveal how strong is the relation between the wrong products picking and the delays occurring and the cost of the activities, or if the correct guidance into the warehouse has a strong relation with the performance of pickers. An analysis utilizing 1-sample t-test, 2-sample t-test, or ANOVA (or proportions tests and Chi-square analysis for percentages of labor and equipment utilization) can extend further the inferences of the Correlation and Regression Analysis by comparing the picking/packing completion times (picking, transportation from storage area to picking area, packing) by different pickers, for different product categories, and in different sections in order to understand the reasons affecting the whole process.

4.4.10.3.4 Improve

The Improvement Actions-LSS Initiatives for the improvement of picking/packing process are a result of the Analyze phase and aim to the advancement of the activities through technological solutions or reconfiguration of the warehouse. Five LSS initiatives are suggested in total, starting from the utilization of RFID technology for the tracking of the picked and packed products of each order in order to prevent wrong SKUs picking and packing. The usage of AR is another LSS Initiative which can actively help and improve pickers navigation in the DC and as a result reduce the time of picking/packing and the errors. For this initiative, employees should be trained in order to be familiar with this technology. A further improvement is the utilization of autonomous vehicles and robots, for picking, transportation to packing area, and packing, which will communicate through IoT sensors and will be connected with the WMS for the determination of their moves. This improvement action can reduce the cost and picking errors even more and can be exclusively used or along with employees in order to reduce their working load and be more productive. In addition, for the transportation of the products from storage to picking and to packing areas convey belts can be used for the reduction of delays and the movements in the warehouse by employees or robots. Finally, for the implementation of all the aforementioned improvements, the reduction of picking/packing times, and the better utilization of the resources the reconfiguration of the picking/packing area/lanes should be undertaken, taking under consideration the space needed for the execution of activities, distances to be covered and their proximity.

The completion of every of the five LSS initiatives should be followed by a re-measurement of the results of the improvements in order to be ascertained that they are effective. Before the investment in new technologies or the establishment of managerial changes, a simulation model of the process can be developed in order to identify whether the metrics are improved. For example, in the picking/packing process the utilization of equipment and labor can be checked, or the time needed for the completion of picking/packing per order/pallet/shift, or the delays occurring during the process and the queues that may be created in picking orders due to the delays of the previous, in order to find out whether the TO-BE process, after the picking sectors reconfigurations or the insertion of technologies, is led to the reduction of execution times and delays, and if the labor effort (e.g., using AR, autonomous vehicles-robots, convey belts) is improved. These improvements are very important, as they can lead to a significant productivity increase and cost (labor and administrative) decrease of the process.

4.4.10.3.5 Control

In the case of picking/packing activities, the data which are proposed to be measured are continuous or percentages. So, for the controlling of the improved processes I-MR charts and X Bar-R Charts should be utilized for the controlling of the time needed for picking and packing, the time that labor and equipment are utilized, or the faults (wrong products picked). The errors in products picking can be also measured with percentage, as well as the utilization of labor and equipment. In this case Laney P charts can be used.

4.4.11 Distribution Plan Configuration LSS Initiatives

4.4.11.1 LSS Improvement Area Diagram

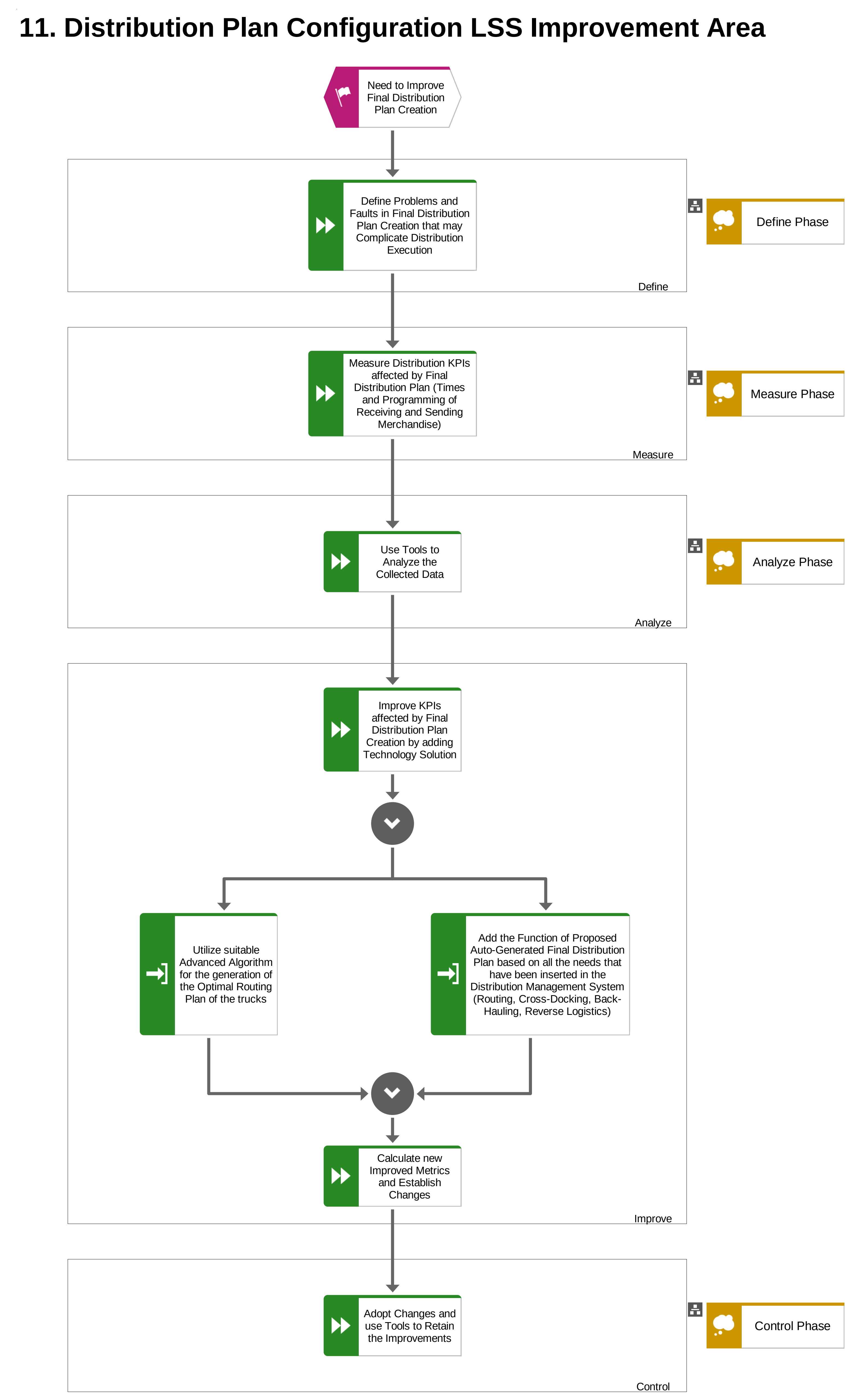


Figure 4.37. EPC diagram of Distribution Plan Configuration LSS Improvement Area

4.4.11.2 Activities connected with this LSS Improvement Area

- 2.1.22. Flow-through Cross-dock Merchandise
- 3.1.2.6.8. Add Back-Hauling and Empty Pallets Return to the Plan for each case
- 3.1.16.7. Create the Final Distribution Plan through the System (after Picking Completion)

4.4.11.3 Description of the DMAIC steps and LSS Initiatives

4.4.11.3.1 Define

This phase aims to the identification of the problems and the factors affecting the configuration of the distribution plan. The company with the utilization of the suitable Define tools based on its needs can identify what are the areas, regarding the configuration of the distribution plan, which need to be improved. Usual problems occurring are the delays of preparing the distribution plan due to the non-existence of the necessary information on time, the omissions of specific activities (e.g., back-hauling) that should be included in the distribution plan, and the not appropriate selection of the way that the routing of the distribution plan will be executed.

4.4.11.3.2 Measure

The Measure phase encompasses the collection of data related to the problems of the configuration of the distribution plan identified during the Define phase. Data can be collected regarding the time that the distribution plan need to be prepared by the Planner, as any delay can lead to problems in other processes, such as cross-docking. The percentage of the times that the distribution plan has omissions can be also calculated as it can affect the correct fulfillment of orders. In addition, the performance of the existing routing plan can be measured in terms of delays occurring in the delivery of orders to stores or via the transportation cost.

4.4.11.3.3 Analyze

In the configuration of the distribution plan improvement projects, the analysis can start with boxplots or stacked-bar charts (both are included in the Charts and Graphs category) in order to visualize the data collected in the Measurement phase about the time that is needed for the configuration of the distribution plan, and the percentage of omissions occurring in the plan respectively. A 5-Whys analysis, FMEA, Pareto Analysis or Fishbone diagrams can be utilized for the identification of the most important factors affecting the delays in the preparation of the distribution plan, or in the delivery of orders. With these types of analysis, the factors negatively affecting the transportation cost can be also identified (e.g., number of unnecessary itineraries, long distances, etc.) Correlation and Regression Analysis can, then, be utilized to reveal how strong is the relation between the factors identified in the previous analysis with the transportation cost. An analysis of the 1-sample t-test, 2-sample t-test, or ANOVA (or proportions tests and Chi-square analysis for percentages of distribution plans without omissions) can be utilized for the checking of the performance of distribution plans in terms of delays, transportation cost, omissions, and correct fulfillment of orders and needs of the distribution in different times of the year or in seasons with specific needs. In this way the company can find out whether the different occasions have an impact on the generation of distribution plan.

4.4.11.3.4 Improve

The Improvement Actions-LSS Initiatives for the improvement of the configuration of the distribution plan process are a result of the Analyze phase and aim to the advancement of the activities through technological solutions. Two LSS initiatives are suggested in total, starting from the utilization of suitable advanced algorithms for the generation of the optimal routing plan of the trucks with the aim of the transportation cost reduction by decreasing distances or unnecessary itineraries, and adding activities such as back-hauling in the plan. In the case of retail companies VR (vehicle routing) algorithms, with variations, can be developed in order to fulfill their needs. For example, the integration of distribution time windows (VRTW) along with the limitation of specific trucks capacities (CVRTW), or the need for multiple trips by the trucks (VRMT) along with the needs for backhauling (VRB) can be combined in order to build a first robust approach, which can take under consideration the primary needs of the companies. In addition, AI VR algorithms can be used as a more contemporary solution which, apart from the factors that have described, can also include in their calculation the demand (based on data from forecasting system), traffic patterns and the flow of previous generated and executed distribution plans in order to improve the next ones. The second LSS initiative is an expansion of the first and proposes the insertion of the function of auto-generated distribution plan by the DMS, based on all the needs that should be taken under consideration (optimal routing, back-hauling, cross-docking execution, and even plan of the itineraries of reverse logistics)

The completion of every of the two LSS initiatives should be followed by a re-measurement of the results of the improvements in order to be ascertained that they are effective.

4.4.11.3.5 Control

In the case of the configuration of the distribution plan, the data which are proposed to be measured are continuous or percentages. So, for the controlling of the improved processes I-MR charts and X Bar-R Charts should be utilized for the controlling of the time needed for the preparation of the distribution plan, or for the controlling of the transportation cost. The percentage or the number of times that the plan has omissions can be controlled via Laney U and P charts.

4.4.12 Loading LSS Initiatives

4.4.12.1 LSS Improvement Area Diagram

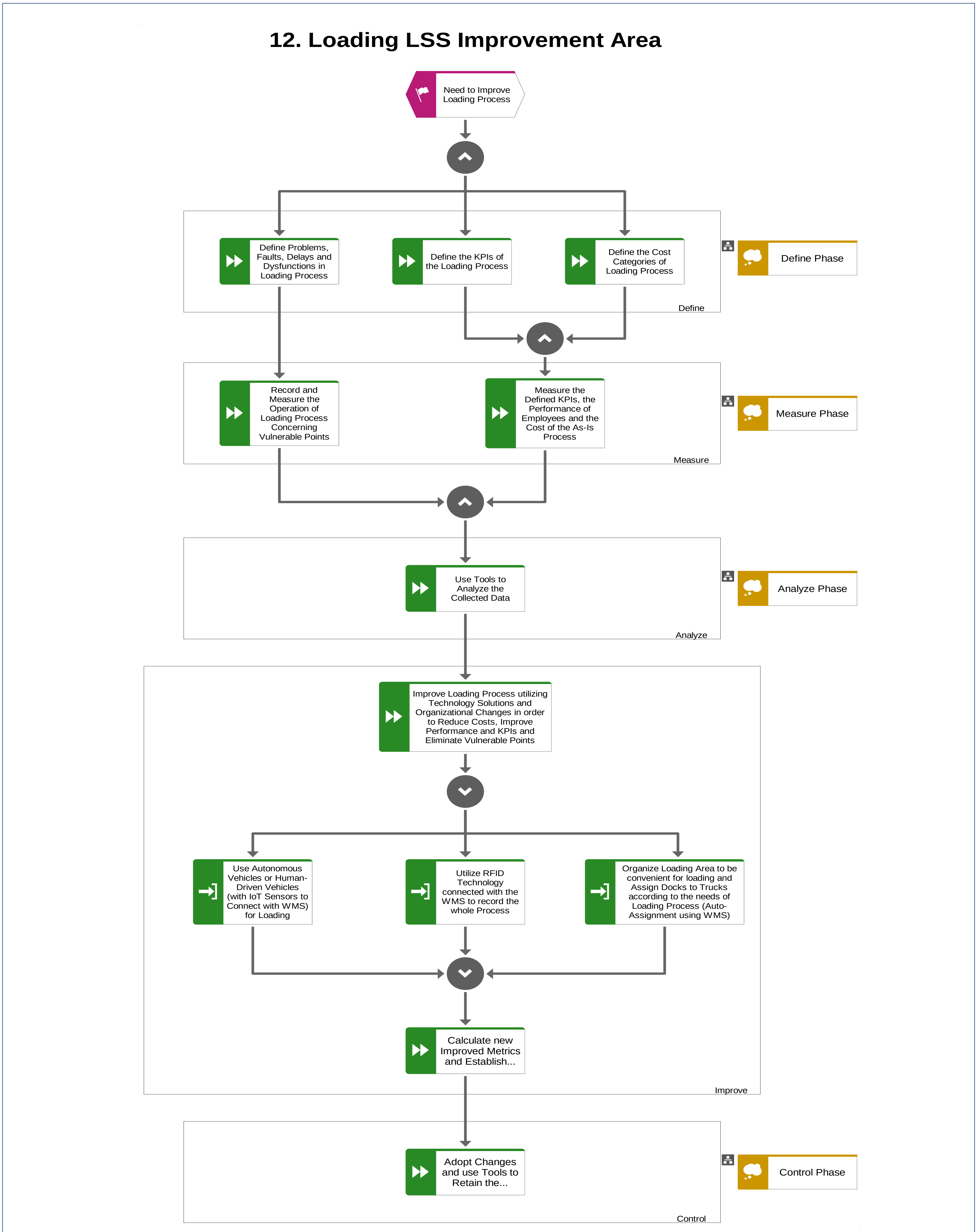


Figure 4.38. EPC diagram of Loading LSS Improvement Area

4.4.12.2 Activities connected with this LSS Improvement Area

- 3.1.19.8. Scan (RF, RFID) and Confirm the Merchandise to be loaded
- 3.1.19.9. Load Trucks

4.4.12.3 Description of the DMAIC steps and LSS Initiatives

4.4.12.3.1 Define

This phase aims to the identification of the problems and the factors affecting the loading of trucks. The company with the utilization of the suitable Define tools based on its needs can identify what are the areas regarding the loading process which need to be improved. Usual problems occurring are the delays of loading trucks, the loading of wrong pallets/boxes to wrong trucks, and the damage of merchandise during the process. These problems can be depicted to KPIs such as loading time per order or number of loadings execution per shift or wrong loadings per day. In this phase, the definition of the cost categories regarding the loading process can be defined, such as labor cost and administrative cost.

4.4.12.3.2 Measure

Data can be collected regarding the time that is needed for the completion of the loading process of each order, and the percentage of merchandise that is damaged per day and per product category during the loading process. In addition, the percentage concerning the loading of wrong orders to wrong trucks can be measured during a shift or a day. These three measurements lead to the data needed for the KPIs described in the Define phase. The calculation of the total cost, taking under consideration all the categories contributing to the cost of loading, is also significant in order to examine the effect of each process component to the AS-IS process and which should be the starting point of improvements.

4.4.12.3.3 Analyze

In the configuration of the loading improvement projects, the analysis can start with boxplots and time series plots or stacked-bar charts (both are included in the Charts and Graphs category). Boxplots and time series plots can visualize the data collected in the Measurement phase about the time that is needed for the loading of the trucks per shift or per dock or per day. Stacked-bar charts can be utilized for the depiction of the percentages of wrong loadings or the percentages of damaged merchandise per product category. A 5-Whys analysis, FMEA, Pareto Analysis or Fishbone diagrams can be utilized for the identification of the most important factors affecting the time of trucks loading (for the identification of factors leading to delays), the damaging of merchandise, and the loading of wrong merchandise to wrong trucks, or even the not loading of merchandise. Subsequently, Correlation and Regression Analysis can be utilized to reveal the relation between the factors identified in the previous analysis with the loading cost. An analysis of the 1-sample t-test, 2-sample t-test, or ANOVA can be used for the checking of performance of loading tasks in terms of completion time by comparing several samples coming from different shifts and employees, different warehouse, different sections of warehouse, different type of merchandise route prior to loading (cross-docking or from storage), and different products categories. All these comparisons can lead to conclusions about the effects on cost. Taking under consideration the same factors of analysis, 1-sample or 2-sample proportions tests and Chi-square analysis can be utilized to check if there is a variation in the averages of the percentages concerning the loading of wrong orders to wrong trucks and damaged merchandise.

4.4.12.3.4 Improve

The Improvement Actions-LSS Initiatives for the improvement of loading process are a result of the Analyze phase and aim to the advancement of the activities through technological solutions and changes in the loading area. Three LSS Initiatives are suggested in total, starting from the utilization of RFID technology, connected with the WMS, in order to record the whole loading process and eliminate the errors in loading leading, consequently, to the reduction of delays. Through WMS, the auto-assignment of trucks to docks can be also inserted for the acceleration of the process (particularly cross-docking) and the assurance of the loading of the correct products to the correct trucks. A supplementary Improvement Action is the organizing of the loading area by adding appropriate signs (guiding lines, smoother ramps, railings, and barriers, etc.), extending the space, and separating each dock for movements for loading of stored merchandise or cross-docking respectively, in order to prevent the damaging of products and to complete the activities faster. Finally, apart from the introduction of human-driven vehicles, which will be connected with the WMS, utilizing IoT technology to receive instant information about which pallet/box to load for the reduction of faults, time and effort, the usage of autonomous vehicles is proposed, as well, that will receive directions and will communicate with each other via IoT technology, reducing the labor cost.

The completion of every of the three LSS initiatives should be followed by a re-measurement of the results of the improvements in order to be ascertained that they are effective. Before the investment in new technologies or the establishment of managerial changes, a simulation model of the process can be developed in order to identify whether the metrics are improved. In the case of the Loading process, a comparison between the AS-IS and the TO-BE situation regarding the delays of trucks loading during the different shifts, the queues of trucks that are created due to the delays and the loading lead time of pallets/loading orders can be conducted via simulation models, after the proposal of improvement actions. In this way, useful inferences can be extracted on whether the better organization of the loading area, the improved assignment of trucks to docks, the introduction of RFID scanning, or the utilization of advanced loading vehicles (human-driven or autonomous) can lead to the improvement of the described metrics and as a result to the reduction of the labor effort, and of the labor and administrative cost.

4.4.12.3.5 Control

In the case of the Loading process, the data which are proposed to be measured are continuous or percentages. Thus, for the improved processes including continuous data I-MR charts and X Bar-R Charts should be utilized for the controlling of the time needed for the loading activities or for the delays occurring to be within the predetermined limits. The percentages or count values of loading wrong orders/merchandise to wrong trucks and the damages of products can be monitored via Laney U and P charts.

4.4.13 Distribution LSS Initiatives

4.4.13.1 LSS Improvement Area Diagram

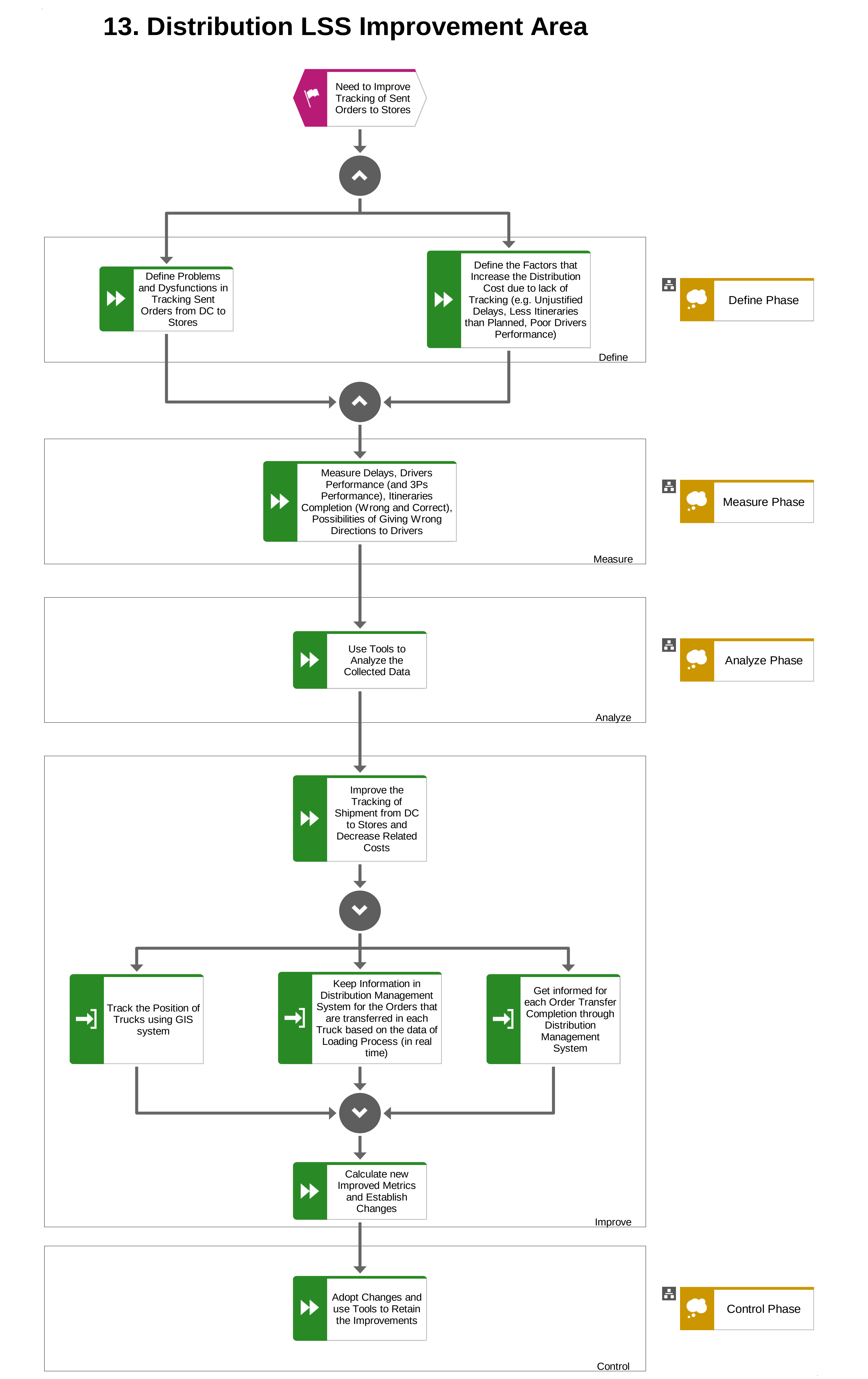


Figure 4.39. EPC diagram of Distribution LSS Improvement Area

4.4.13.2 Activities connected with this LSS Improvement Area

- 4.1.5. Record Shipment

4.4.13.3 Description of the DMAIC steps and LSS Initiatives

4.4.13.3.1 Define

The Define phase aims to the identification of the problems and the factors affecting the distribution of merchandise to stores and more specifically the recording of the shipping. The company with the utilization of the suitable Define tools based on its needs can identify what are the areas regarding the distribution process which need to be improved. Usual problems occurring are the delays of the execution of itineraries, and the execution of fewer itineraries than those planned, leading to stock-outs. In addition, the following of another route by the driver than that suggested by the routing algorithm, without the permission of the Logistics Department, or the existence of a special occasion can lead to increased transportation cost. The performance of drivers is also a factor that affects the efficient execution of the process and acts as a KPI.

4.4.13.3.2 Measure

The Measure phase encompasses the collection of data related to the problems of the distribution activities identified during the Define phase. Data can be collected regarding the time that is needed for the completion of the distribution process of each order to each store from which the delays will occur. In addition, the number of itineraries that are completed in each shift is a crucial metric, along with the non-existence of excess delays, to measure the performance of both own truck drivers as well as, 3PDs. A calculation which can lead to a useful inference is the percentage of the wrong execution of orders delivery (e.g., wrong products to wrong store) due to the incorrect directions given to the driver by the Logistics Department.

4.4.13.3.3 Analyze

In the distribution improvement projects, the analysis can start with boxplots and histograms or stacked-bar charts (both are included in the Charts and Graphs category). Boxplots and histograms can visualize the data collected in the Measurement phase about the time that is needed for the delivery of orders to stores by different drivers, or by 3PDs in order to check their performance, as well as the number of itineraries per shift in order to check whether they are executed as planned. A stacked-bar chart can be used for the depiction of the percentages of wrong directions given to drivers per warehouse, during a specific time period. 5-Whys analysis, Pareto Analysis or Fishbone diagrams can be utilized for the identification of the most important factors affecting the time of distribution and lead to delays, or the non-completion of the programmed itineraries. Subsequently, Correlation and Regression Analysis can be utilized to reveal how strong is the relation between the delays in distribution, or the uncompleted itineraries with the stock-outs. This type of analysis can also reveal the relation between the incorrect direction to drivers with the delays. An analysis of the 2-sample t-test, or ANOVA can be used for the checking of performance of own drivers to the 3PDs in terms of delays and uncompleted itineraries. Moreover, a 2-sample proportion test or Chi-square analysis can compare the average percentages of the distribution of wrong orders to wrong stores due to incorrect directions, from different DCs.

4.4.13.3.4 Improve

The Improvement Actions-LSS Initiatives for the improvement of the recording of distribution are a result of the Analyze phase with the goal of the advancement of the activities, through technological solutions, and aim to reduce delays and uncompleted itineraries, as well as the delivery of wrong orders to wrong stores. Three LSS initiatives are suggested in total, starting from the introduction of a GIS system which will track the position of trucks executing the shipments. In this way, the routes that are followed by the trucks can be monitored and checked to follow the routing plan forcing in the avoidance of the unjustified delays. The GIS can also help in the measurement of the distances that trucks are covering that affect the distribution cost. The second LSS initiative that is proposed is the keeping of information of the orders (or merchandise) that are transferred by each truck (in real time) in the DMS, based on the data of the loading process. This improvement combined with GIS, can contribute to the monitoring of the merchandise on trucks on every route, resulting in the timely notification of the driver that he/she transfer wrong merchandise to wrong store, due to incorrect directions, preventing the covering of a long distance. Finally, the company can get informed by the DMS for the completion of each order transfer completion in real-time. Consequently, the incorporation of the GIS and this function of the DMS can prevent the non-execution of a percentage of the planned itineraries, as the Logistics Department with the combination of the collected data will exactly know, in real time, the number of planned itineraries that a shift can execute.

The completion of every of the three LSS initiatives should be followed by a re-measurement of the results of the improvements in order to be ascertained that they are effective.

4.4.13.3.5 *Control*

In the case of the distribution process, the data which are proposed to be measured are continuous, count or percentages. Thus, for the improved processes including continuous data I-MR charts and X Bar-R Charts should be utilized for the controlling of the time needed for the delivery activities or for the delays occurring to be within the predetermined limits. The percentages of transferring wrong orders to wrong stores, or the number of non-executed planned itineraries can be monitored via Laney U and P charts.

4.4.14 Collaboration with Vendor LSS Initiatives

4.4.14.1 LSS Improvement Area Diagram

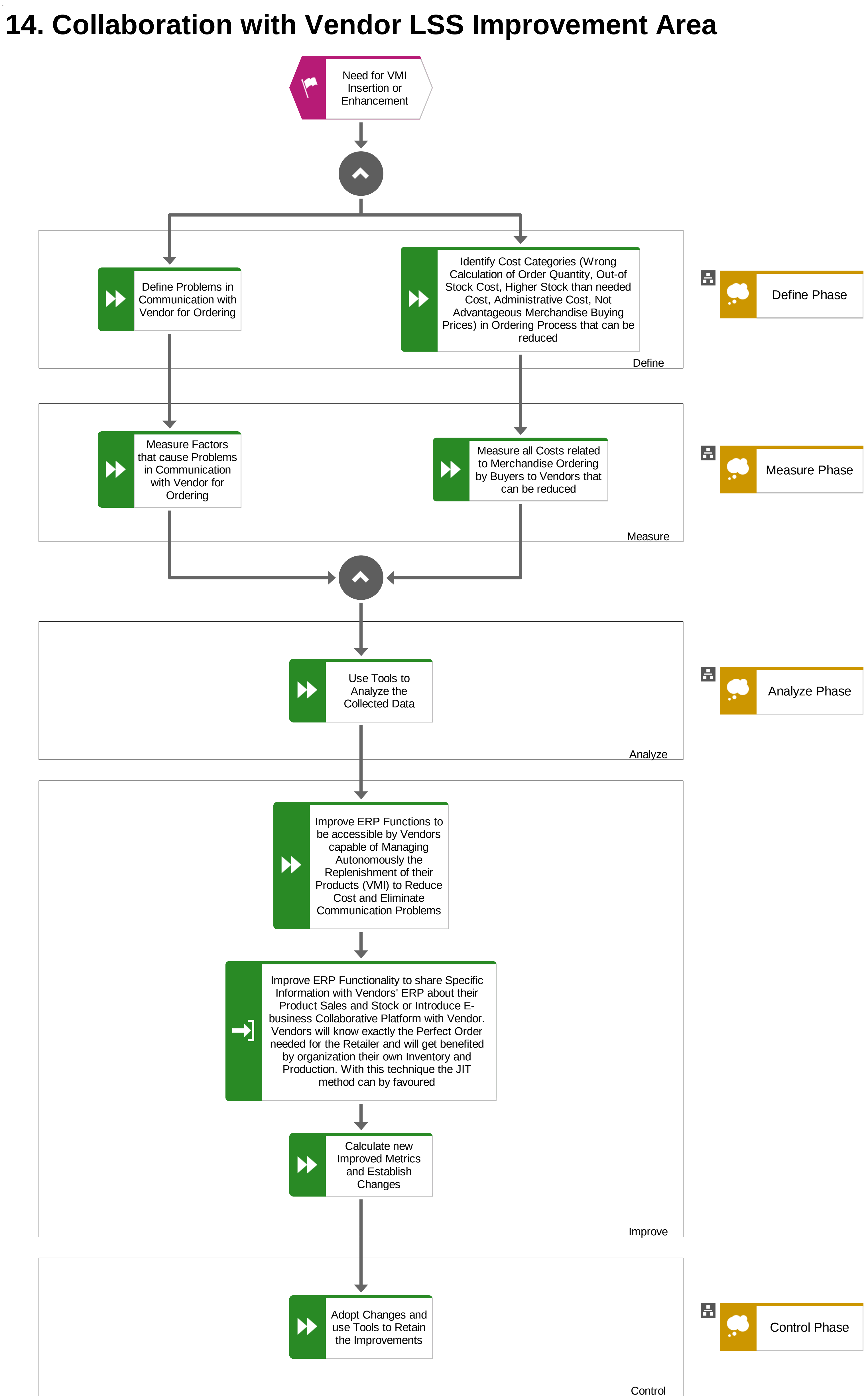


Figure 4.40. EPC diagram of Collaboration with Vendor LSS Improvement Area

4.4.14.2 Activities connected with this LSS Improvement Area

- 5.1.14.13. Inform Vendor's System Environment for its Products Sales and Stock

4.4.14.3 Description of the DMAIC steps and LSS Initiatives

4.4.14.3.1 Define

The Define phase aims to the identification of the problems concerning the collaboration with Vendors for merchandise replenishment. The company with the utilization of the suitable Define tools based on its needs can identify what are the areas regarding the collaboration with Vendors for replenishment. A usual problem occurring is the poor communication with the Vendor for ordering the and this is the reason that some orders are not executed well. For example, Vendors may have not anticipated an order of high-level quantities of products and not have in stock. In addition, in this phase the company can identify the factors affecting the overall cost and are related to the replenishment of products, such as the wrong calculation of order quantity, out of stock cost, excessive stock cost, administrative cost of ordering, and not advantageous buying prices of merchandise.

4.4.14.3.2 Measure

The Measure phase encompasses the collection of data related to the problems of the collaboration with Vendors identified during the Define phase. Data can be collected regarding the communication with Vendor, such as the percentage of times that Vendors cannot cover the replenishment needs of the company because they were not ready for big orders. Moreover, the factors cost concerning replenishment can be measured. For example, the percentage of the times that stockouts occur or there is a need for excessive stock in order to be sure for the adequate replenishment. The percentage of times that the prices of products are higher than expected can be also calculated, as well as the administrative cost of ordering.

4.4.14.3.3 Analyze

In the improvement of the communication with Vendors for replenishment projects, the analysis can start with bar charts or stacked-bar charts (both are included in the Charts and Graphs category). These charts can depict the percentages of times that several Vendors cannot send the orders, in a timely manner, because they were not prepared for big quantities or for the production of specific products categories. A Pareto Analysis can be utilized for the checking of the effect proportion of all the factors described that affect cost (and even more according to the company). An analysis of a 2-sample proportion test or Chi-square analysis can compare the average percentages of the times that different Vendors cannot cover the replenishment needs of the retailer in order to reveal whether the performance of Vendor is poor or the performance of Buyers is problematic.

4.4.14.3.4 Improve

The Improvement Actions-LSS Initiatives for the improvement of the collaboration with Vendor are a result of the Analyze phase and aim to the advancement of the activities through technological solutions and are based on the rational of information sharing and collaboration between Vendors and Retailers, which can be evolved to a Vendor-Managed Inventory (VMI) with exclusive responsibility of the Vendor to replenish its own products, when needed. Specifically, the improvement of ERP functionality of both the Retailer and the Vendor is proposed for the directly sharing of information about the sales of vendors' products and stock. In addition, for the same reasons an e-business collaborative platform between the retailer and the vendor can be established. In this way, the Vendor will exactly know the "perfect" order that the retailer needs, on a timely manner, and its production and inventory can be previously adjusted, as the data of sales and stock will be transparent, for an improved service level to retailer. The result will be the reduction of stockouts or excessive stock for the retailer, as the replenishment will be consistent and could lead to the enhancement of the JIT replenishment method with multiple small batches of received orders in the appropriate time. The introduction of VMI, which give full control in Vendor for its products replenishment, apart from the already described benefits of the other solutions, can also lead to reduced prices of products, as the Vendor will manage and arrange the plan of its production on its own and, as a result, its cost can be decreased. In addition, the Retailer will not have the cost of managing and tracking the stock of some product categories, reducing its administrative cost. However, the VMI has as a prerequisite the capability of the Vendor to support such an initiative and to be trusted by the Retailer. Consequently, the selected Vendors are usually large companies with the capacity, technological equipment and software, and the investment margin to undertake this responsibility, which can bring several benefits to them, though. Finally, the administrative cost of retailer can be also reduced, as there will be no need for the Buyers to execute a percentage of ordering activities.

The completion of LSS Initiatives should be followed by a re-measurement of the results of the improvements in order to be ascertained that they are effective.

4.4.14.3.5 Control

In the case of the collaboration with Vendor, the data which are proposed to be measured are percentages. Thus, for the improved processes Laney P charts can be utilized for the checking of VMI performance in terms of replenishment needs fulfillment, and stock-outs or excessive stock of specific important product categories.

4.4.15 Reverse Logistics LSS Initiatives

4.4.15.1 LSS Improvement Area Diagram

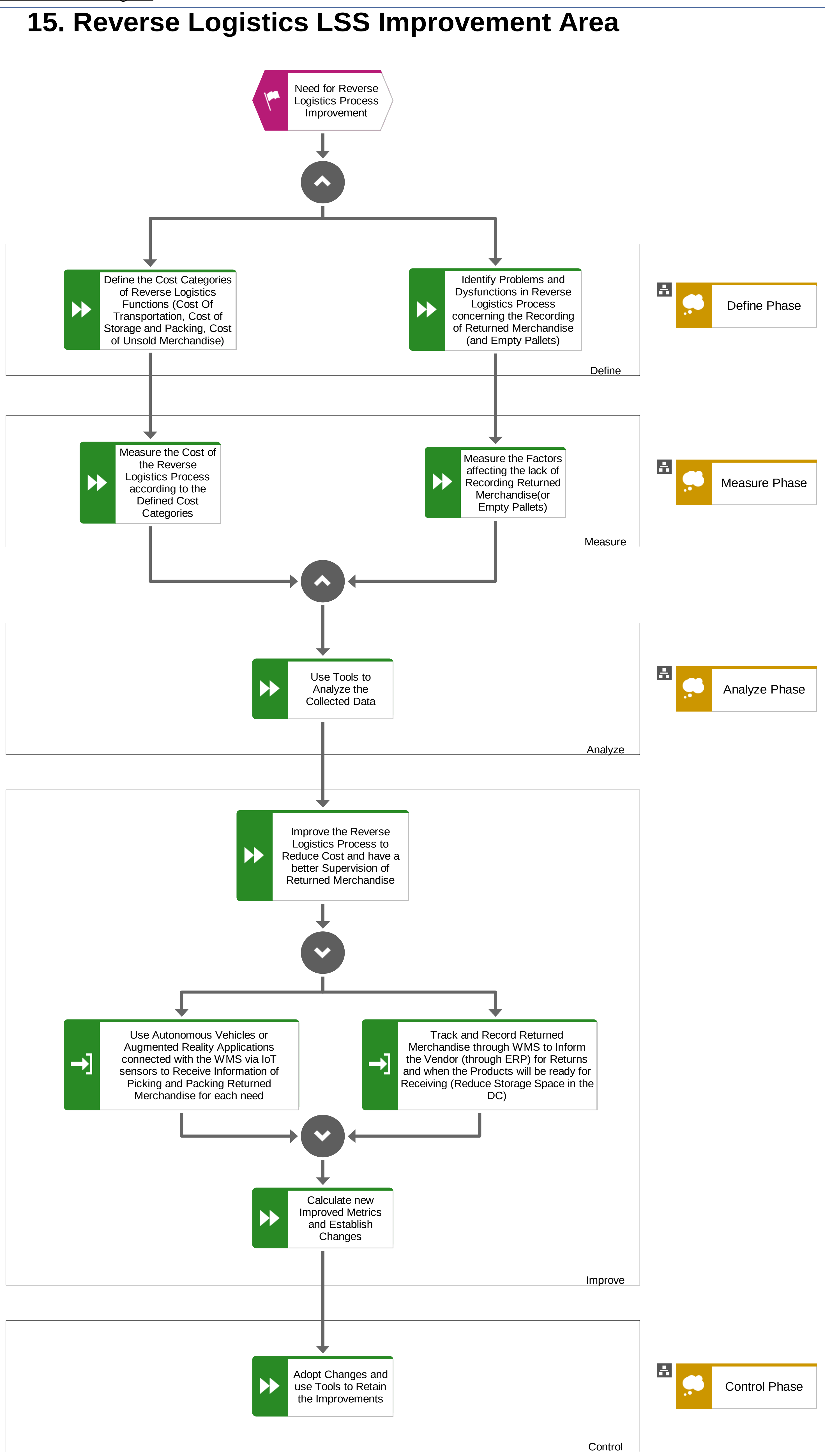


Figure 4.41. EPC diagram of Reverse Logistics LSS Improvement Area

4.4.15.2 Activities connected with this LSS Improvement Area

- 6.1.9. Retrieve and Pack Returned Merchandise according to each need
- 6.1.10. Schedule Pick-Up/Delivery of Products

4.4.15.3 Description of the DMAIC steps and LSS Initiatives

4.4.15.3.1 Define

This phase aims to the identification of the problems concerning reverse logistics activities. The company with the utilization of the suitable Define tools based on its needs can identify what are the areas regarding the management of returned products. Usual problems occurring is the lack of tracking and recording of the merchandise that is returned to the warehouse by the Department of Logistics in order to timely prepare the storage area, the returning of a high volume of pallets/boxes which cannot be stored properly because of lack of space, and the ineffective gathering (picking/packing) of returned products in order to be transferred to their final destination without taking up useful storage space for long time. In this phase, the cost categories of reverse logistics can also be defined to be calculated in the Measure phase, including cost of transportation, cost of storage and picking/packing, and cost of unsold merchandise (an improvement action for the reduction of this cost category has been already proposed by adding better forecasting systems and algorithms, and auto-order function).

4.4.15.3.2 Measure

The Measure phase encompasses the collection of data related to the problems of the reverse logistics activities, identified during the Define phase. Data can be collected regarding the number of boxes/pallets/products that are returned, on a daily basis, without the Department of Logistics is notified about this return. The time that is needed for the picking/packing of the returned merchandise can be also measured, along with the time that merchandise is staying in the storage area. The Department of Logistics can select the storage time of returned product categories that would like to measure (e.g., products of high volume or large quantities, or sensitive products). In addition, the cost categories that have been identified in the Define phase can be calculated.

4.4.15.3.3 Analyze

In the improvement projects of reverse logistics, the analysis can start with boxplots or time series plots (both included in the Charts and Graphs category) for the depiction of the time that specific categories of returned products stay in the storage, or how the quantity of products staying in the storage area fluctuates over time. A Fishbone Diagram or 5-Whys Analysis can be utilized for the identification of the causes that lead to the retainment of large quantities of returned products to storage area (e.g., lack of tracking of the incoming products for the arrangement of their redirection, delays in picking/packing activities of returned products due to overload of other picking/pacing activities for the distribution preparation). Correlation and Regression Analysis can be used for the identification of the relation between the delays in picking/packing or the number of times that the Logistics Department is notified about returns, and the existence of a high stock of returned products. An analysis of a 2-sample t-test or ANOVA can reveal whether the product category, or the notification of incoming returned merchandise are important for the storage of larger or smaller proportions of returns respectively.

4.4.15.3.4 Improve

The Improvement Actions-LSS Initiatives for the improvement of reverse logistics process are a result of the Analyze phase and aim to the advancement of the activities through technological solutions. Two LSS initiatives are proposed aiming to the better tracking and recording of the returned products and in the faster preparation of them in order to be redirected. Specifically, the first LSS initiative concentrates to the introduction of the tracking and recording of the returned merchandise (through ERP) and through WMS when they get in the warehouse in order to inform Vendors (or other stakeholders such as retail companies of returned products) when the returned merchandise can be received, resulting in the faster free-up of storage space. For the facilitation of the quicker preparation of returned merchandise to be redirected (picking/packing of returned products) the utilization of AR could be useful for pickers, or the utilization of autonomous vehicles connected with the WMS and communication via IoT technology could help in the faster execution of the reverse logistics activities that are delayed, due to pickers workload in the distribution preparation activities. Both LSS initiatives help in the reduction of the cost related to reverse logistics as the preparation of returned products for redirection, as well as their stay in the storage area are accelerated.

The completion of LSS Initiatives should be followed by a re-measurement of the results of the improvements in order to be ascertained that they are effective.

4.4.15.3.5 Control

In the case of the reverse logistics, the data which are proposed to be measured are continuous. Hence, for the improved processes I-MR charts or X bar-R charts can be utilized for the checking of the quantities of returned products that are stored or the time that are remaining in the storage area.

5 Case Study of LSS RSCPR

5.1 Case Study Background

The objective of this case study, through the implementation of LSS, following DMAIC phases as described in the LSS RSCPR, is the testing of the model after its configuration for its final validation by a real-life example in a retailer. The benefits that the retailer can attain by the improvement actions proposed in the LSS RSCPR are also examined in order to find out whether the following of the steps described by the reference model, along with the active participation of the management team of the company, which is a CSF for the success of LSS initiatives, can have the anticipated positive impact on the operation of the company. Both qualitative and quantitative tools are used in this study in order to better analyze the data and decide on the improvements. The parameters affecting the application of the appropriate changes, according to LSS principles, are also taken into account.

The company of this case study is a Greek retailer, subsidiary of a multinational company, operating 510 stores in Greece and employing 14,000 people. The Department of Logistics manages three main DCs which are organized in sections. The first DC is Mandra 1 which is supported by two more warehouses, named Mandra 2 and Magoula. The second DC is in Oinofyta, consisting of five sections: Oinofyta Fruits & Veggies, Oinofyta Fridge, Oinofyta Meat, Oinofyta Super Fresh, Oinofyta Deep-Freezing. The third DC is Sindos, consisting of six sections: Sindos Mixed, Sindos Fruits & Veggies, Sindos Fridge, Sindos Meat, Sindos Super Fresh, Sindos Deep-Freezing. Each of these sections includes products that are stored, managed, and loaded according to their specific needs.

The discussion and the implementation of the case study occurred in the Department of Logistics of the company. The organizational chart of the roles of the Department that were participated in the case is depicted in **Figure 5.1**.

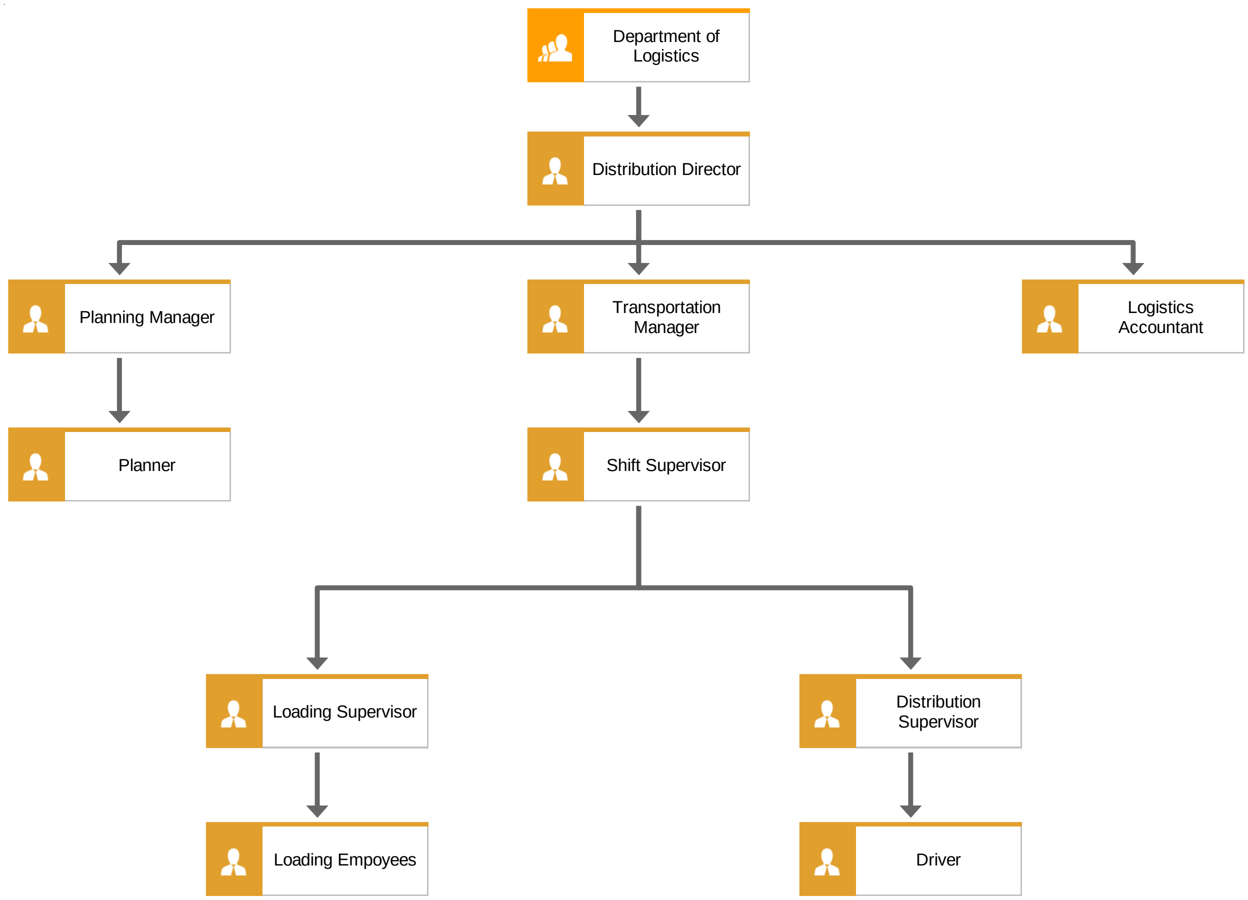


Figure 5.1. Organizational chart of the participants in the case

By analyzing the processes modeled by the LSS RSCPR, in which the studied company has contributed to, and by discussing them with the Distribution Director of the company, it was decided to conduct an LSS project, following the instructions presented in the LSS initiatives of the reference model regarding the "loading to trucks" process. This process was selected for two main reasons. The first one was that the steps of this process were simpler than others of the logistics department and it was considered as a good opportunity for the introduction of LSS principles from a relatively simple and straightforward process. The second reason was that the improvement of this process was embedded in a general improvement program of the loading facilities of Mandra 1 DC that had been started by the company this specific period. Thus, a further proposed improvement in the already existing upgrading program was desirable by the management team. The project of this case is a pilot project in Mandra 1, where the most serious problems in loading process appeared, with the intention to test the introduced improvement and investment for further implementation in the rest of the DCs.

In **Figure 5.2,** a brief presentation of the process and the activity of the LSS RSCPR, that was selected for improvement along with the tools that were used and the improvement action that was adopted, is depicted. The company had no previous experience in LSS and CI initiatives, so guidance was necessary for the successful deployment of the project. In order to detect the problems of this process and to collect as many data as possible, a series of meetings and interviews were conducted. Specifically, during June 2021, eight meetings and eleven interviews took place to address the problems and collect the data regarding the loading process. The participants of the project were from the Department of Logistics, including the Distribution

Director, the Planning Manager, four Loading Supervisors, four Shift Supervisors, two Transportation Supervisors, two Planners, and Loaders of different shifts.

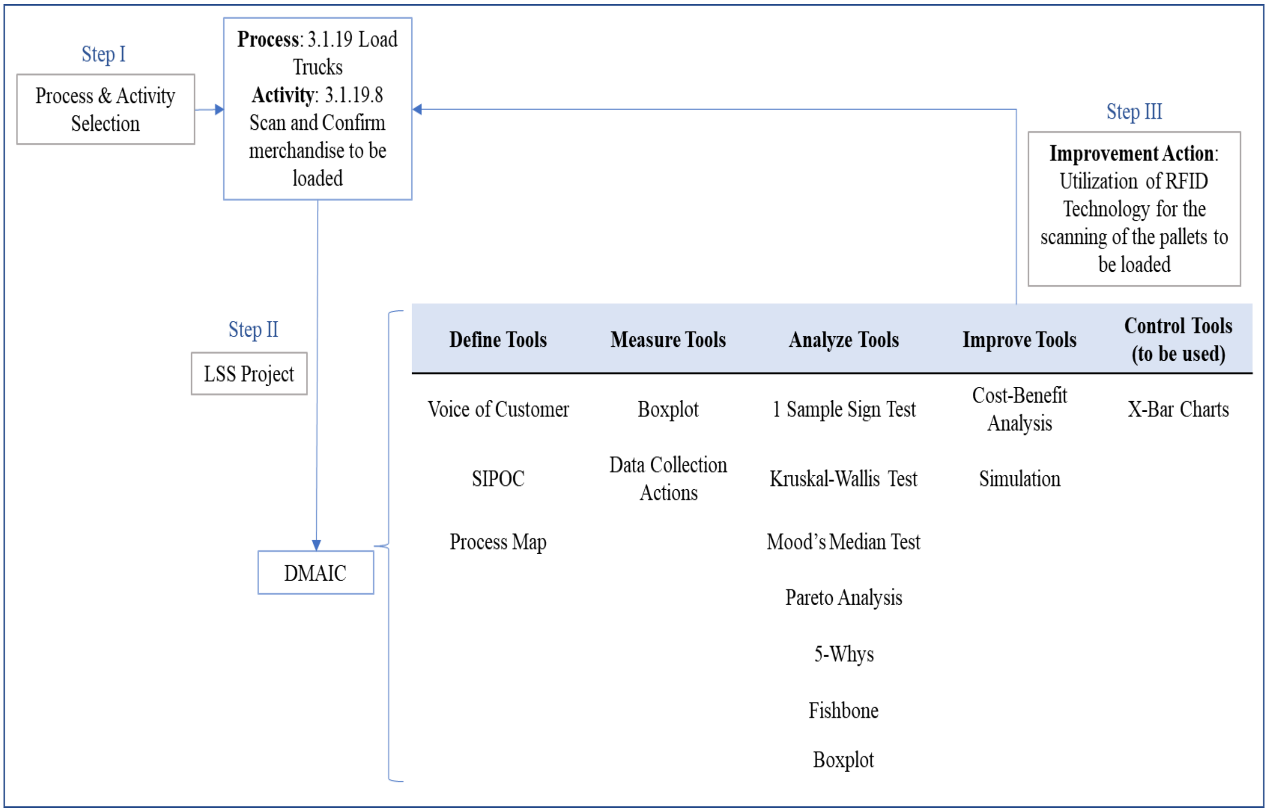


Figure 5.2. Brief presentation of the steps followed in the case study

5.2 Case Study Methodology

The analysis of the case, that will be conducted in order to examine LSS implementation in a Greek retailer, will follow an integrated framework consisting of the phases of DMAIC method and the steps that Yin (2009) proposed for case studies. These steps are separated into two phases: data collection and data analysis. The integrated methodological framework is represented in **Figure 5.3**, where DMAIC steps are matched with data collection and data analysis. The type of case study is characterized as descriptive and the analysis of the data is carried out according to the logic models pattern, since the chain of events occurred is studied in a linear way; inputs, results, and cause–effect relationships between them are taken under consideration, and a comparison between theory and practice is executed in order to evaluate the case (Yin, 2003).

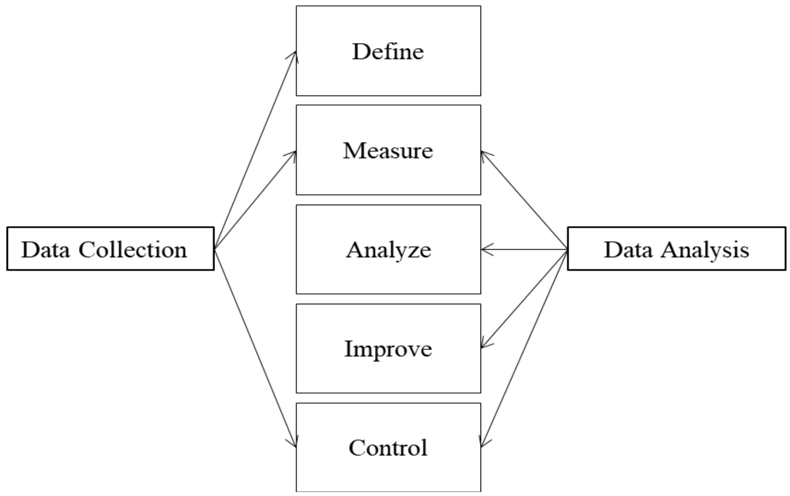


Figure 5.3. Methodology of the case study

5.3 DMAIC Implementation

5.3.1 *Define Phase*

The purpose of this phase is to clearly identify the problem, the requirements, the objectives of the project, as well as the scope of the project. The starting point, according to the reference model, is the definition of the problems that the company confronts during the loading process, through brainstorming sessions (interviews and meetings) with the stakeholders of the process, and the extraction of useful information from the customers of the process which led to the configuration of the Voice of Customer (VOC). The analysis of the process components is presented in **Table 5.1** through SIPOC. A process map of the Loading process is depicted in **Figure 5.4**, based on the "3.1.19 Load Trucks" modeled process of the LSS RSCPR, as this is the process that the company follows.

The two problems which have been detected by the customers of the process are:

- The drivers were complaining about the delays in loading, and
- the stores have observed that there were occasions when orders arrived without one or more pallets.

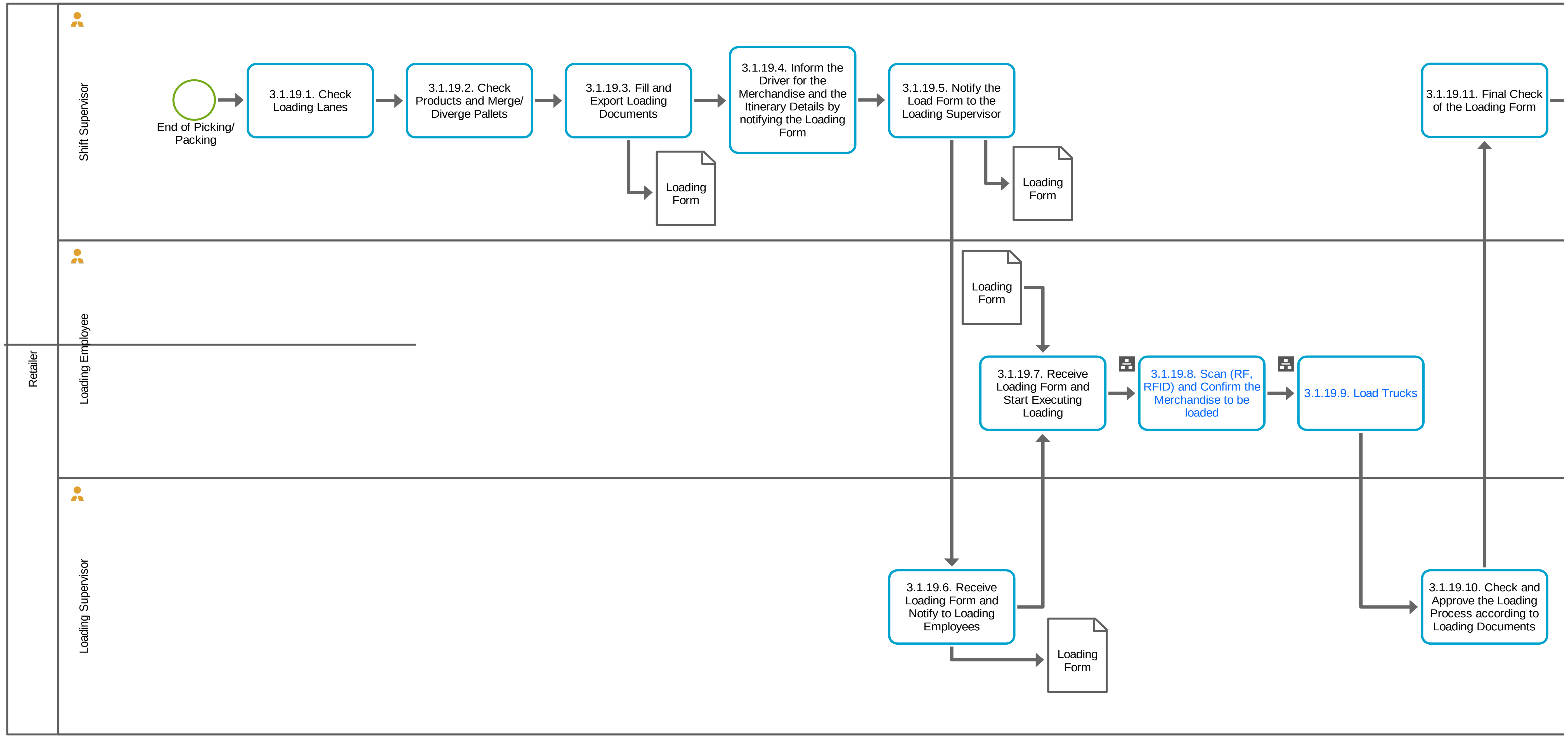
In the conversations with the management team, the observations of the process customers were confirmed. A connection among these two problems was also stated, as the delays are many times a result of the loading times and the rush for the confrontation of the delays could lead to errors in the loading process, such as the incomplete loading. Thus, the meetings with the managers of the Distribution Department led to three main needs that should be taken under consideration:

1. The reduction of the loading lead times
2. The reduction of the delays for the loading of trucks
3. The reduction of the possibility of a pallet/ trolley not to get loaded

Table 5.1. SIPOC Analysis

Supplier	Input	Process	Output	Customer
Picking/ Packing	Pallets/ Trolleys	Loading merchandise to trucks	Loaded trucks	Drivers, Stores

3.1.19 Load Trucks



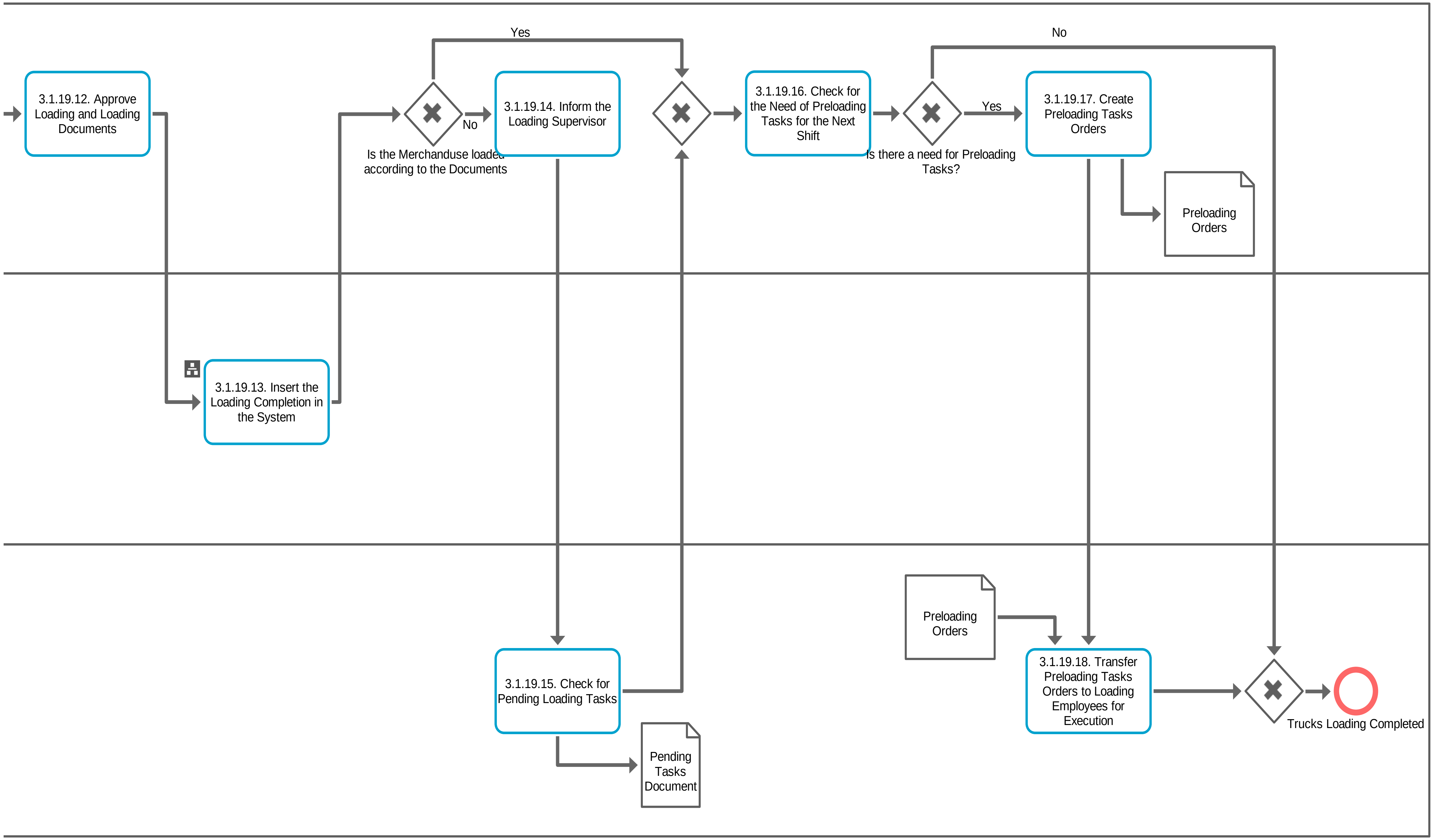


Figure 5.4. Process Map

The second step of the Define phase, as it is described by the steps of the LSS Improvement Area diagram of the loading process, is the determination of the cost categories and the KPIs. This information will lead to the responding measurements in the Measure phase. In the case of the studied company the cost is measured using the man-hours and the performance of the process is measured with the pallets per loader per shift. The cost of the man-hour will be used in the analysis of the introduced improvement in order to infer whether it is reduced. In addition, the suggested KPI by the company is expanded for this case in the measurement of number of errors occurring during the loading process in order to find out the number of pallets that are not loaded due to loaders faults.

5.3.2 *Measure Phase*

This phase starts with the determination of the ideal sample in order to facilitate the calculations of the Analyze phase that follows. The sample concerns the loading times of the pallets/ trolleys. For the measurement of loading times, it was decided that random loading times of loading orders should be recorded in each shift for an operating week (5 days) from the 6th to the 11th of June. However, before these measurements, the company provided the researcher with the archived loading times for each section of each DC for the month of May. By analyzing these data coming from about 210,000 loading orders, as shown in the boxplot of **Figure 5.5,** the maximum time needed for the loading of pallets of a loading order was 57 minutes and the minimum was 1 minute, depending on the quantity of the pallets that each loading order contained. The larger the number of pallets per loading order the more time was needed for their loading in trucks. Following the formula **MSS = ((2 x standard deviation) / Precision)^2**, provided by Brook (2017), the minimum sample size needed was calculated. The standard deviation is calculated by a rule of thumb provided by Brook (2017) who suggests using the formula **SD = (max value - min value) / 5.** As a result, the sample needed for the analysis of this process was found to be 225, considering that the desired precision is 1.5 minute as this is this was measured to be the average time for a pallet to be loaded (with a range of ±20 seconds). Thus, the measurement of approximately 250 loading orders was decided per day, including all three shifts of the day, for one week. The selected week was the second of June, as it was a typical week of loading orders according to the schedule of the company for all the DCs, without increased demand or seasonality, but with specific peak days that were important to be included and measured. The boxplot also reveals that the Mandra 1 DC and the Fruits & Veggies section of the Oinofyta DC have the highest loading times; information that was confirmed by the Distribution Director of the company, too. A big number of outliers is also presented in the boxplot; however, it was expected due to the existence of some time-consuming loading orders, especially in the days of the week that the whole country is served by the DCs. In addition, compared to the big number of the loading orders that were available for elaboration from the first week of June (around 83.000), these outliers were very few. Outliers were generally presented in the measurements, but they were excluded in all the analyses that were later conducted in the Analyze phase.

In the measurement, the days of the week with the highest peak were also taken under consideration. There is a difference among different DCs, that’s why the measurements of Oinofyta start on Sunday 6/6/2021, which is the day with the highest peak of the week, and for example in Mandra 1 the starting day was Monday 7/6/2021, as the peak days of this DC are Mondays and Thursdays, when trucks are loaded for distribution of merchandise throughout the whole country. The emphasis is also given on the night shift of the operationally full days as there are many more loading orders. For this reason, from the 250 measurements of peak days almost half of them come from the night shift.

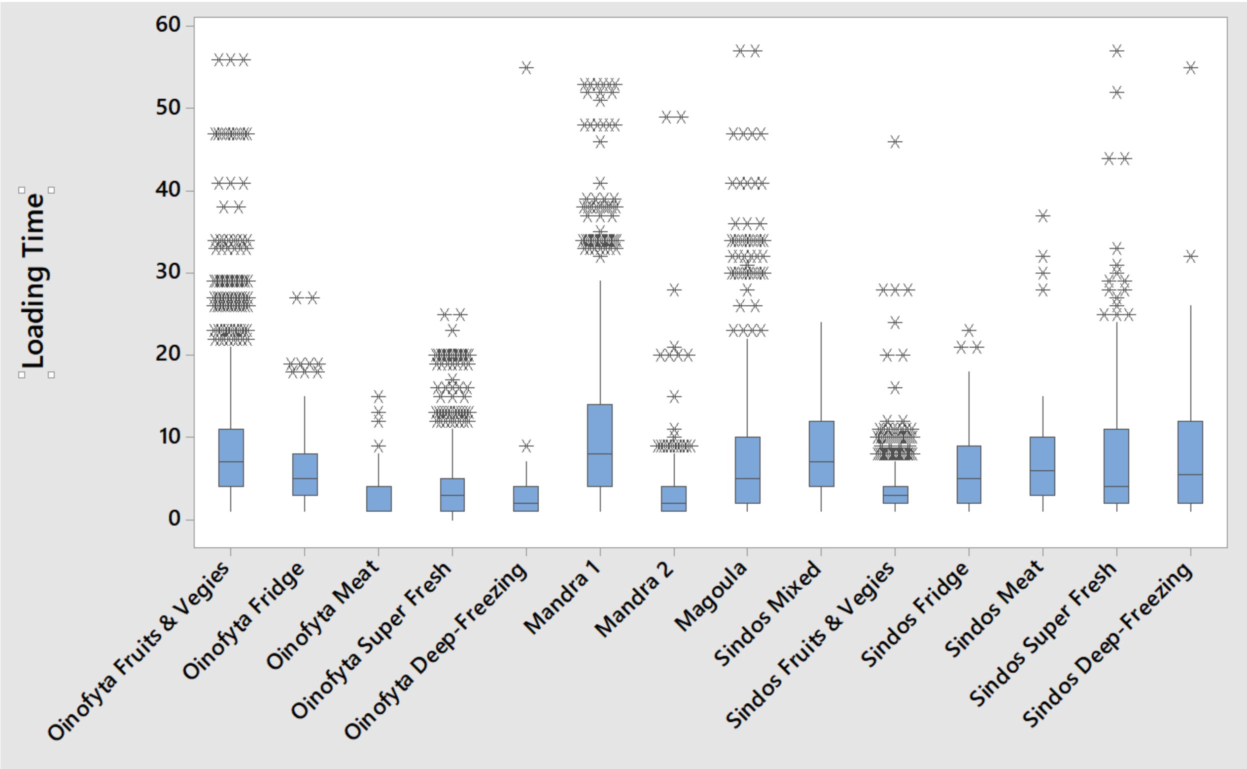


Figure 5.5. Boxplot for the comparison of the loading lead times of loading orders among different warehouses

In addition to the collected loading times, the data that were also measured during the project, or were measured by the company were that:

- The time needed for a loader to load a pallet/ trolley is on average 1.5 minutes with a deviation of ±20 seconds.
- Every loader, based on their performance (KPI), can load from 300 to 350 pallets/ trolleys in each shift. This information was recorded in the KPIs of the company.
- The cost of the loading process is calculated using the man-hour of the loaders, which equals to 7€/man-hour (total) according to the salary record of the company. This information can be used to calculate the cost reduction by the proposed improvement.
- About 10,000 pallets/ trolleys are loaded, on a daily basis, from all the DCs. 5,000, with a deviation of ±500, are loaded daily from the Mandra 1 DC.

5.3.3 *Analyze Phase*

This phase focuses on the detection of the causes of the two main problems that were determined in the Define phase, the long delays in the days of the week that the stores of the whole country are served and the not loading of pallets/ trolleys in the trucks by mistake. According to the managers of the company the DC Mandra 1 confronts the biggest problem with delays and not loading of pallets, as in this DC the half of the pallets of daily activities are loaded. The causes of delays were identified and are presented in a Fishbone diagram (**Figure 5.6**). The majority of them have been already identified by the company and were confirmed by the observation of the process. For example, the insufficient space for the high volume of merchandise that is loaded daily by the Mandra 1 DC was detected by the company before this LSS project and the building of a new warehouse sector has already started. The scanning of pallets is characterized as time-consuming, as it needs the 1/3 of the time of each pallet loading, on average 30 seconds out of the 1.5 minute. This was an inference that was extracted during the project by the observation of the loading process. This time can be reduced by reviewing the four steps of this activity, including scanning of the barcode document with the loading order, scanning of the barcode of the loading lane, scanning of the barcode of the pallet and scanning of the barcode of the truck. For this reason, a low-level process map was configured for the detailed presentation of the steps of the scanning activity 3.1.19.8 (Scan and Confirm the Merchandise to be loaded) of the 3.1.19 (Load Trucks) process, as shown in **Figure 5.7**. A Pareto chart was also constructed (**Figure 5.15**), summarizing the effect of the remaining four reasons of delays (lack of adequate personnel, picking/packing delays, malfunctions or damages of trucks, not timely arrival of trucks). The data that were used for the quantification of the causes of delays were provided by the company which is recording them and extracts the percentages based on historical data. The Loading Supervisor of the company mentioned that almost 15 pallets per day remained unloaded because of loaders' mistakes, which may lead to store stockouts for one to two days, until the next delivery window of the store comes, and loss of earnings. For the reason of the not loading of pallets, the tool of 5-Whys was utilized, as presented in **Figure 5.8**. This problem is a result of the scanning method, again, as it was observed during the Measure phase of the project. Specifically, the loader prefers not to follow the four steps for each pallet, but to scan the loading order, then insert the lane manually to the RF scanner, scan the pallet and then insert the plate number of the truck manually to the RF scanner, without loading the pallets in order to not do meaningless moves from the pallets to truck and then again back to the lane for the completion of the loading. This scanning bypass, particularly in the large loading orders, lead to mistakes and not loading of pallets.

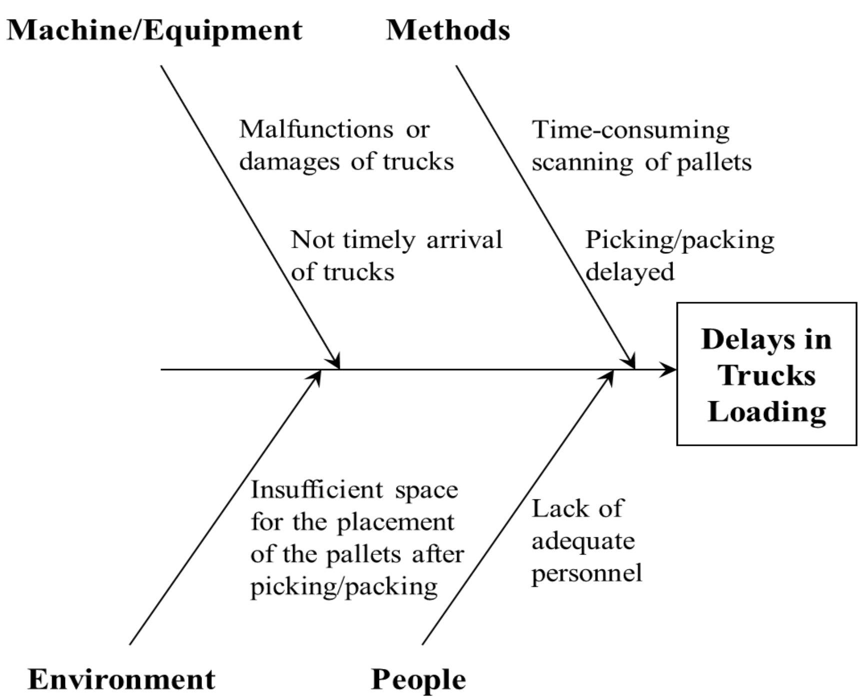


Figure 5.6. Fishbone Diagram

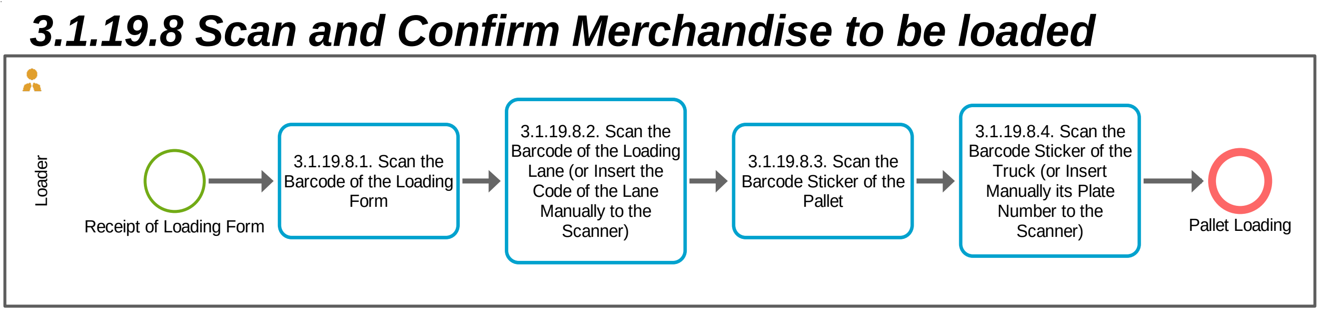


Figure 5.7. Steps of the Scanning Activity of the Loading Process

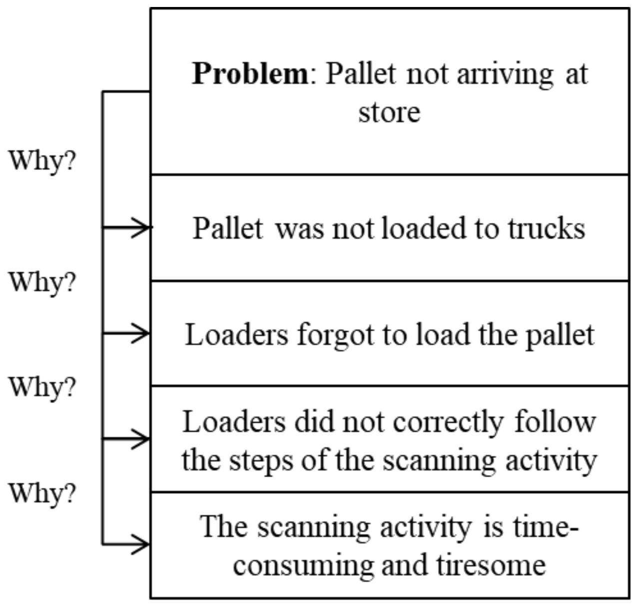


Figure 5.8. 5-Whys answering why a pallet is not arriving at store leading to out-of-stock

Before the analysis of the sample of collected data it is important to check if the sample of around 250 loading orders is representative. For this reason, a 1-sample sign test was conducted, through Minitab, as shown in **Figures 5.9, 5.10** and **5.11**, for Mandra 1, Oinofyta Fruits & Veggies and Sindos Mixed. The 1-sample sign test was selected because the data collected are not normal. The descriptive statistics of the three warehouses' total loading orders times for the second week of June are presented in **Figure 5.12**. The numbers of loading orders for this week were 22,422 for Mandra 1, 11,912 for Oinofyta Fruits & Veggies and 7,480 for Sindos Mixed. Mandra 1 was selected as it will be the DC that will be extensively studied after the suggestions of the company and the result of the boxplot which shows that it has the biggest loading times, followed by Oinofyta Fruits & Veggies. These two cases will be compared in order to investigate their real difference. Sindos Mixed will also be compared to Mandra 1, as they are two warehouses with the same configuration. From the descriptive statistics, the median of Mandra 1 also appeared to be the highest (the median is selected because the data are not normally distributed).

The Null hypothesis of the 1 sample sign tests for Oinofyta Fruits & Veggies, Mandra 1 and Sindos Mixed is that the median of the loading times of the sample differs from the median of the loading times of the total number of the loading orders of the second week of June that were later provided by the company.

The result of Oinofyta Fruits & Veggies, as shown in **Figure 5.9**, is that p-value = 0.4583 > 0.05, that is the significance level selected for Confidence Interval of 95%. Hence, the null hypothesis cannot be rejected, and the inference is that the medians are not different. The same pattern is followed by the sign tests of Mandra 1 (**Figure 5.10**) and Sindos Mixed (**Figure 5.11**), with p-values of 0,7983 and 0,4795, respectively, indicating that the medians of the sample and the total are not different. Thus, the sample is representative to the total population.

Sign Test for Median: Oinofyta Fruits & Vegies

Sign test of median = 6,000 versus ≠ 6,000

	N	N*	Below	Equal	Above	P	Median
Oinofyta Fruits & Vegies	251	12	104	31	116	0,4583	6,000

Figure 5.9. 1 sample sign test for Oinofyta Fruits & Veggies

Sign Test for Median: Mandra 1

Sign test of median = 8,000 versus ≠ 8,000

	N	N*	Below	Equal	Above	P	Median
Mandra 1	263	2	120	18	125	0,7983	8,000

Figure 5.10. 1 sample sign test for Mandra 1

Sign Test for Median: Sindos Mixed

Sign test of median = 6,000 versus ≠ 6,000

	N	N*	Below	Equal	Above	P	Median
Sindos Mixed	198	1	86	36	76	0,4795	6,000

Figure 5.11. 1 sample sign test for Sindos Mixed

Descriptive Statistics: Oinofyta Friuts & Veggies Total; Mandra 1 Total; Sindos Mixed Total

Variable	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3
Oinofyta Friuts & Veggie	8,536	0,159	7,734	1,000	4,000	6,000	10,000
Mandra 1 Total	10,417	0,149	8,769	1,000	4,000	8,000	14,500
Sindos Mixed Total	7,672	0,150	5,622	1,000	4,000	6,000	9,500

Figure 5.12. Descriptive Statistics for Oinofyta Fruits & Veggies, Mandra 1 and Sindos Mixed total number of loading orders

A Mood's Median Test was also conducted for the comparison of the medians of the Mandra 1 loading times against those of the Oinofyta Fruits & Veggies and those of the Sindos Mixed. The comparison is presented in **Figures 5.13 and 5.14**. In both cases the p-value equals zero (smaller than 0.05), which indicated that there is a difference in the medians of the loading times for 95% Confidence Interval. The tests also show that, with 95% confidence, the median of Mandra 1 loading times are 0.9 to 3 minutes longer than those of Oinofyta Fruits & Veggies and 2 to 3 minutes longer than Sindos Mixed. These results confirm that the attention should be paid in the reduction of the loading times of Mandra 1. This observation is enhanced by the information which was given by the company, which pointed out that the loading delays in Mandra 1 DC are the largest of all DCs and can reach two hours in the peak days, as it was observed in the night shifts of the peak days (Monday and Thursday), and is confirmed by the historical record of the company and the interviews with the employees, who pointed out that this is a repeatable pattern that occurs every week.

Mood Median Test: Loading Times versus Warehouse Oinofyta-Mandra

```
Mood median test for Loading Times
Chi-Square = 12,12    DF = 1    P = 0,000

                                                    Individual 95,0% CIs
Warehouse Oinofyta-Mandra    N≤   N>  Median  Q3-Q1  +---------+---------+---------+------
Mandra 1                    120  143    8,00   8,00   (------------------*---------)
Oinofyta Fruits & Vegies    153   98    6,00   6,00  *---------)
                                                     +---------+---------+---------+------
                                                    6,0       7,0       8,0       9,0

Overall median = 7,00

A 95,0% CI for median(Mandra 1) - median(Oinofyta Fruits & Vegies): (0,90;3,00)
```

Figure 5.13. Mood's median test for the comparison of the medians of Mandra 1 and Oinofyta Fruits and Veggies

Mood Median Test: Loading Times 2 versus Warehouse Mandra-Sindos

```
Mood median test for Loading Times 2
Chi-Square = 13,87    DF = 1    P = 0,000

Warehouse                                     Individual 95,0% CIs
Mandra-Sindos    N≤   N>  Median  Q3-Q1  --------+---------+---------+--------
Mandra 1        116  147    8,00   8,00           (---------------*-------)
Sindos Mixed    122   76    6,00   4,00  (-------*
                                         --------+---------+---------+--------
                                                6,0       7,2       8,4

Overall median = 6,00

A 95,0% CI for median(Mandra 1) - median(Sindos Mixed): (2,00;3,00)
```

Figure 5.14. Mood's median test for the comparison of the medians of Mandra 1 and Sindos Mixed

The confirmation, by the statistical analysis, of the claim of the company that the focus should be given to Mandra 1, as the loading times are high during the peak days, led the analysis to the investigation of the four causes of delays recorded by the company which also were also described in the fishbone diagram (Figure 5.5). These four causes are depicted in the Pareto Chart of **Figure 5.15**. The chart represents the number of times for May 2021 that a loading order in Mandra 1 DC was delayed, analyzed in the recorded reasons. In total, 30% of the loading orders of the Mandra 1 are delayed being loaded, the majority of which are detected on Mondays and Thursdays of the month (peak days). The main reason of delay is the lack of adequate personnel in almost 68% of the cases, followed picking/packing delays in about 31% of the cases. The other causes are negligible and very rare. As a result, the 99,5% of the delays occurring for two main reasons. However, neither of these two causes can be confronted directly, as the study of picking and packing process concerns another large LSS project by its own, and at the time of this project, the company did not provide the researcher with the necessary data for this project, and the number of active loaders per shift, which is the main factor of delays, cannot be increased as the top management do not intend to hire new personnel. Thus, the delays were decided to be indirectly confronted by the reduction of loading times. In addition, it was proposed to the company to transfer loaders from the morning and afternoon shifts to the peak evening shifts as there is a way of reducing loading times. The company, however, rejected this proposal since the maximum number of loaders that can be occupied in Mandra 1 are 14, due to the narrow loading lanes and the lack of space for free movement; so, if the number of loaders exceeds this calculated limit, then there will be safety problems.

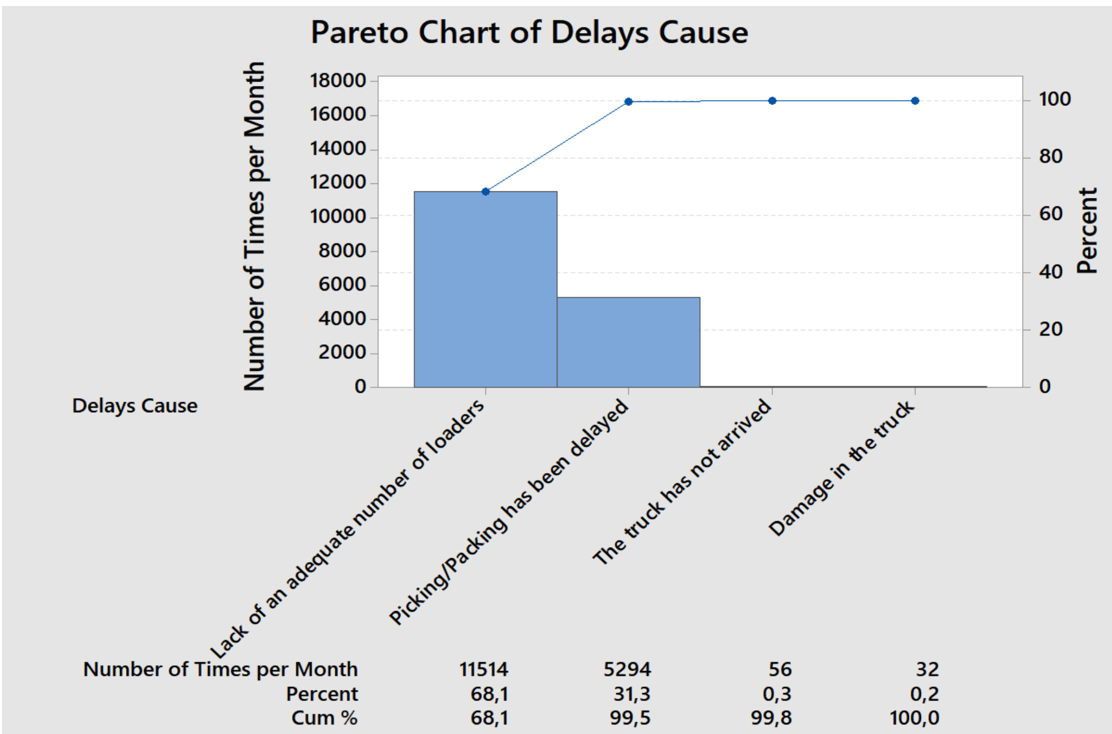


Figure 5.15. Pareto Diagram of the causes of delays

For the better analysis of the loading times of loading orders of Mandra 1 DC, the data collected in the second week of June 2021 were separated in subgroups based on the shift from which they came, as shown in the **Table of Appendix A2**.

The boxplot of **Figure 5.16** which summarizes the data of the different shifts and days, depicts that the loading times of the loading orders of the night shifts of Monday and Thursday are higher, than those of the other shifts. The boxplot also reveals that in the afternoon shifts of these specific days the workload has been already apparent, meaning that the reduction of loading times will be in favour of more shifts and will reduce the delays, as well.

The same conclusion is extracted by a Kruskal-Wallis test which was conducted in order to infer whether there is a difference in the medians of the samples of each subgroup of different shifts. Specifically, a comparison was undertaken between the morning shift (A) and the night shift (C) of Monday (7 June) and

Thursday (10 June), as shown in **Figures 5.17** and **5.18**, respectively. The null hypothesis is that the medians of the loading times of loading orders among different shifts do not differ. The result was that the p-value equals to zero (smaller than 0.05), so we can be 95% confident that the medians differ in both days between the morning and night shift, declaring the workload of these shifts which should be helped by reducing the loading times. This inference is also confirmed by the Kruskal-Wallis test conducted for the Wednesday 9th of June (**Figure 5.16**). This day has a more normal flow among its shifts, without big delays. The result of the test indicates that the medians of loading times of loading orders among the three shifts (A for morning, B for afternoon, C for night) are not different with 95% confidence, as the p-value equals to 0.680 (larger than 0.05) and the null hypothesis cannot be rejected.

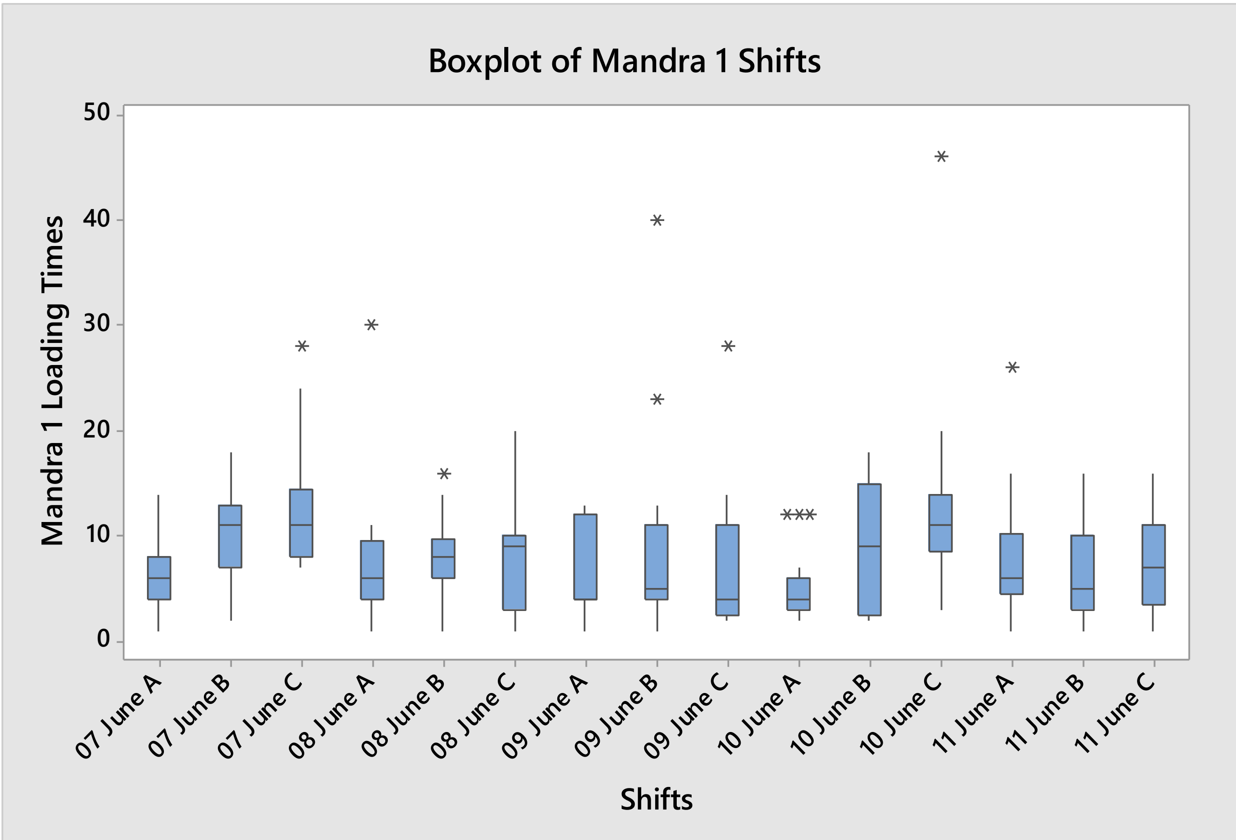


Figure 5.16. Boxplot of loading times for the different shifts of Mandra 1 from 7th to 11th of June

Kruskal-Wallis Test: Mandra 1 Shifts_1 versus Shifts_1

```
Kruskal-Wallis Test on Mandra 1 Shifts_1

Shifts_1    N  Median  Ave Rank      Z
7 June A   15   6,000      11,7  -3,76
7 June C   26  11,000      26,3   3,76
Overall    41              21,0

H = 14,15  DF = 1  P = 0,000
H = 14,41  DF = 1  P = 0,000  (adjusted for ties)
```

Figure 5.17. Krukal-Wallis test for the comparison of medians between Mandra 1 morning shift and night shift on Monday 7th of June

Kruskal-Wallis Test: Mandra 1 Shifts_3 versus Shifts_3

```
Kruskal-Wallis Test on Mandra 1 Shifts_3

Shifts_3     N  Median  Ave Rank      Z
10 June A   17   4,000      13,4  -3,55
10 June C   25  11,000      27,0   3,55
Overall     42              21,5

H = 12,60  DF = 1  P = 0,000
H = 12,74  DF = 1  P = 0,000  (adjusted for ties)
```

Figure 5.18. Krukal-Wallis test for the comparison of medians between Mandra 1 morning shift and night shift on Thursday 10th of June

Kruskal-Wallis Test: Mandra 1 Shifts_2 versus Shifts_2

```
Kruskal-Wallis Test on Mandra 1 Shifts_2

Shifts_2    N  Median  Ave Rank      Z
9 June A   16   4,000      24,1  -0,46
9 June B   17   5,000      27,9   0,85
9 June C   17   4,000      24,4  -0,40
Overall    50              25,5

H = 0,72  DF = 2  P = 0,696
H = 0,77  DF = 2  P = 0,680  (adjusted for ties)
```

Figure 5.19. Krukal-Wallis test for the comparison of medians of all shifts in Mandra 1 on Wednesay 9th of June

5.3.4 *Improve and Control Phases*

The analysis of the data, regarding loading times of loading orders, showed that the concentration of the improvement actions should concern Mandra 1, as from this DC the half of the daily number of pallets is distributed to stores. This DC also has most of the delays, which will indirectly be confronted up to a certain point with the reduction of the loading times. The delays could be better confronted with additional warehouse space and personnel, but there was a limitation set by the company in the number of personnel and the space was predetermined. The managers of the company, though, had understood the need for more space and an upgrade of the space and the interior configuration had been started before the conduction of this LSS project. Thus, the first improvement action, as described in **Figure 4.38**, has been undertaken by the company.

The other two LSS initiatives described by the reference model, regarding the utilization of the autonomous vehicles for the loading process or the introduction of RFID technology made a positive impression to the managers. From the two improvement actions, the utilization of the autonomous vehicles was rejected, for now, due to the high cost of the investment and the need to upgrade the technological infrastructure of the company. For this reason, the insertion of RFID technology was considered as the solution that should be analyzed, as a first step in the modernization of the barcode scanning technique which is used at present. This decision was made based on the culture of CI which advocates in favour of small steps and gradual improvements that will lead to a big positive impact in total.

In order to implement the RFID technology and improve the scanning activities of the loading process, a study about its benefits should be undertaken. The RFID will reduce the scanning steps needed with the barcodes for the loading of the pallet. The agreement and the bottom line of the discussion with the management team of the company was that the scanning of the loading order document barcodes and the truck barcodes will be retained, as it would be difficult to change for now, and RFID antennas-readers will be placed in the gates in order to automatically scan the pallets passing through them, which from now on will be tagged with RFID tags and not barcodes. This change will lead to a non-radical improvement, but to a small first step of the loading process improvement, following the "one step at a time" mentality of CI. The difference will be that in the execution of every loading order the four manual scanning steps (loading order, lane, pallet, truck) will not be necessary for every pallet, but only two manually scanning steps (loading order, truck) and the pallets along with the lanes will be automatically recognized by the system through the RFID tag of the pallets and the code of the RFID reader-antenna of the lane that scans the pallet. In sum, the average of 30 seconds (with a range of 5 seconds) needed for the scanning steps of the AS-IS process for each pallet (according to the measurements of the company) will be eliminated. Specifically, a reduction of 25 seconds can occur with a deviation of 5 seconds. This reduction is explained in **Figure 5.20**. Specifically, it was measured that each step of the scanning lasts for about 10 seconds. The starting point (t = 0) of this activity is the scanning of the barcode of the loading order document. From the four steps of the scanning activity, two time-consuming ones are deleted with the insertion of RFID. Thus, the only scanning remaining is this of the loading order barcode and the barcode of the truck, as the other scanning steps (pallet and lane scanning/recognition) are removed from the activity and automatically performed by the RFID system, as shown in **Figures 5.21, 5.22**. The result is the direct elimination of 20 seconds by the scanning activity. In addition, half of the time of the barcode scanning of trucks is eliminated because the loader does not have to go the truck for scanning of each pallet or to insert the plate number before the execution of pallet loading, but he/she should only scan it after the pallet has passed the RFID gate just after his/her entry in the truck trailer. Thus, the loader will only need five seconds for the last scanning step, as calculated with the help of the company. As a result, the scanning activity from t = 0 will be reduced on average 25 seconds (with a range of ±5 seconds depending on the performance of loader).

This is the first benefit that the RFID implementation will offer in loading times reduction and as a consequence in the delays reduction.

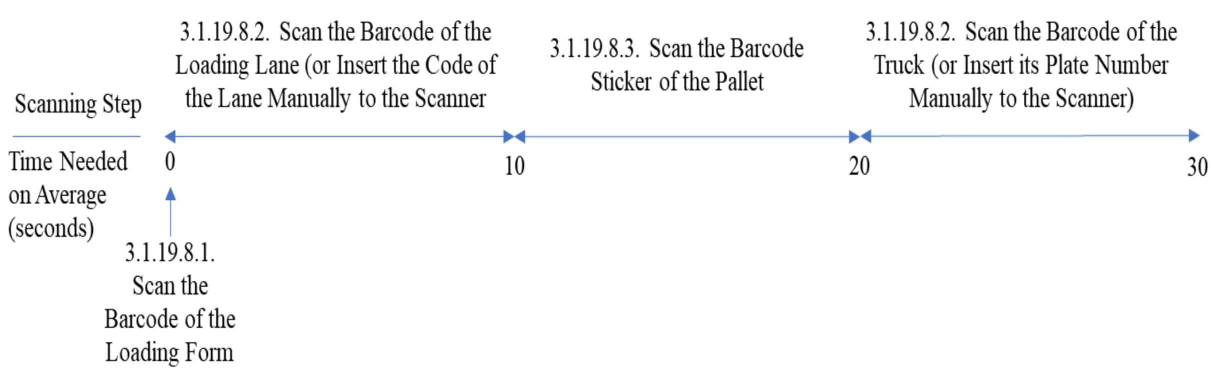


Figure 5.20. Time needed for the scanning steps

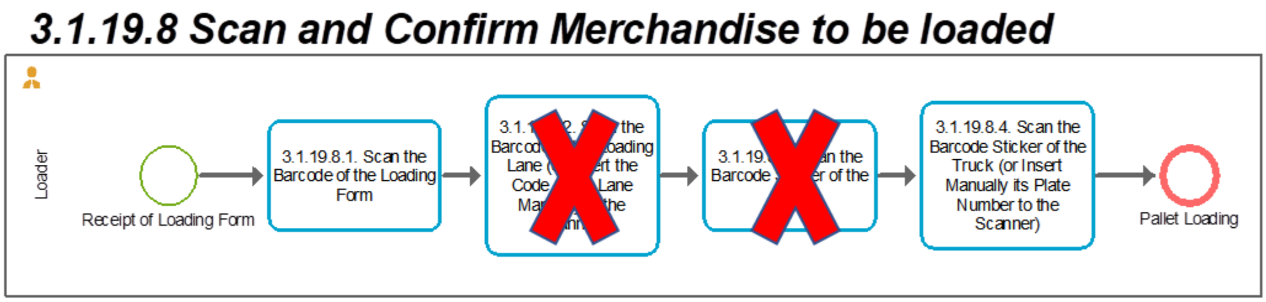


Figure 5.21. The steps that are deleted from the AS-IS scanning activity

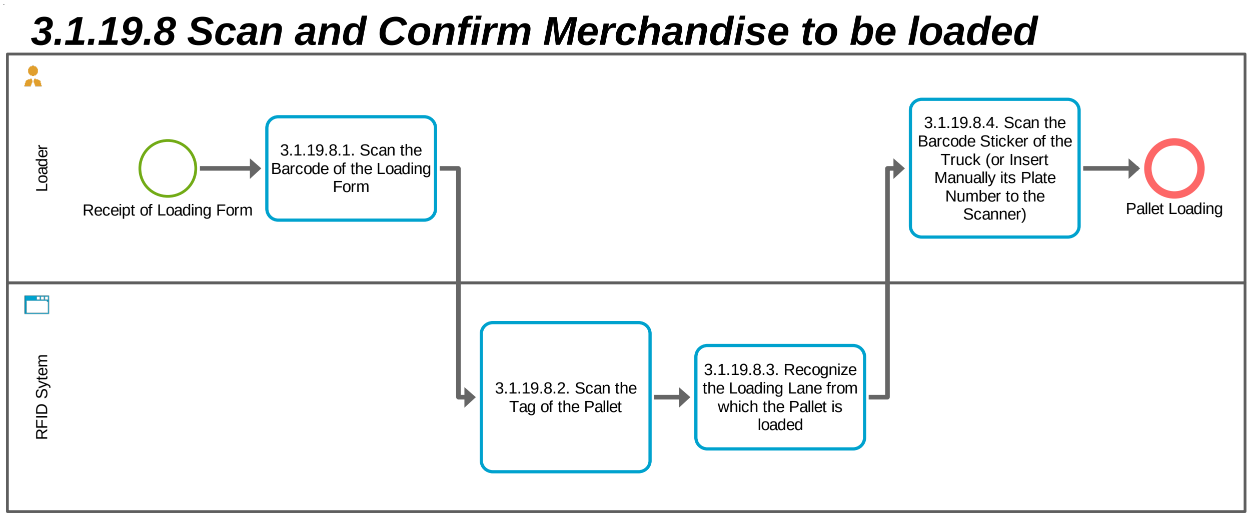


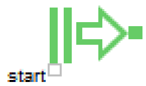
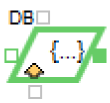
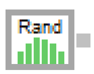
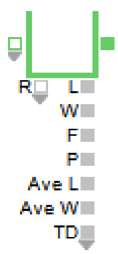
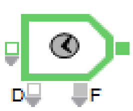
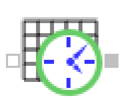
Figure 5.22. The TO-BE steps of scanning activity

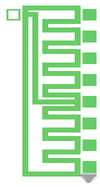
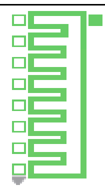
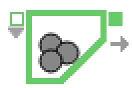
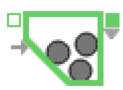
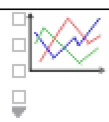
An additional benefit is that the probability of loaders' mistakes, which were happening due to the tiresome activities of the barcode scanning and led to the not loading of roughly 15 pallets per day, along with loss of earnings and stockouts, will be annihilated.

<u>Simulation</u>

For the checking of whether the reduction of the loading times is feasible and what is the extent of this reduction, a simulation model was built for the comparison of the "before" and the "after" situation. For the simulation, the discrete-event method was used by utilizing the *ExtendSim* software. Two different models were constructed for the simulation of the loading process of pallets. The AS-IS model was simulated in order to check and verify the correctness of the model. The aim is to confirm the validity of the AS-IS model by checking the accuracy of the model's representation of the real system (i.e., the loading process). This validation makes sure that the model AS-IS is accurate, and, consequently, the TO-BE model, which is configured based on the AS-IS, is also an accurate representation of the real process. **Figure 5.19** represents the process before the adoption of RFID and **Figure 5.20** represents the process after the RFID implementation. In both models, it was considered that there were no delays due to picking/packing process in order to measure the processing time of the loading process and to focus on the loading activities themselves. The blocks that were used are shown in **Table 5.2**.

Table 5.2. Utilized simulation blocks along with their description

Simulation Block	Description of Utilization
 *Create*	This block is used to create items for the model. In the simulation of the loading process, a batch of pallets is the item that is created based on specific schedule.
 *Set*	The Set block is used for the setting of item properties in the items passing through it. In this model, the quantity of the items created by the Create block is set.
 *Random Number*	This block generated random numbers based on a set distribution. In this model, the Random Number block was assigned to Set block for the generation of the number of pallets.
 *Queue*	Queue was used for the gradual releasing of the items for their processing by activities.
 *Activity*	The activity block was used for the modeling of each active loading position in each shift. The delay of each activity was set to the time that a loader needs to load a pallet, following the normal distribution.
 *Shift*	In this model, the Shift block determines the change of morning, afternoon and night shifts and the available loading positions accordingly. It also programs the blocked loading positions of the morning shift due to the night shift delays.

Simulation Block	Description of Utilization
 *Select Item In*	This block was used for the redirection of the pallets with equal probabilities, sequential, in each loading position, giving priority to the empty loading positions.
 *Select Item Out*	This block was used for the merging of the items, that were processed by each activity, to the exit.
 *Batch*	The Batch block allows many items to be joined in one. In this model, it is used for the batching of the generated pallets into one item/truck.
 *Unbatch*	The Unbatch block produces multiple items from a single item according to the desirable quantity. In this model, this block transforms the trucks into pallets.
 *Exit*	Exit block passes the items out of the simulation.
 *Line Chart*	The Bar Chart was used for the recording of the queue length that was created in specific loading positions of the morning shift due to the delays of the night shift.

The configuration of the model was based on the business rules of the company and on specific assumptions that were made. The characteristics and the data that were used for the simulation in order to check the usefulness of the improvement are summarized as follows:

- The company uses seven different sizes of trucks for the transportation of the merchandise to stores depending on the needs for replenishment and the accessibility to stores. These sizes are 5-pallet trucks, 10-pallet trucks, 12-pallet trucks, 15-pallet trucks, 18-pallet trucks, 33-pallet trucks, and 35-pallet trucks. These trucks are following a predetermined daily schedule for their arrival in the loading lanes. The schedule is configurated based on shifts and includes the type of truck and the time of truck arrival. This schedule has very small changes among the same days of each week, as the replenishment windows of stores do not change and the needs for replenishment (in the number of pallets) in typical weeks are about the same for stores with few variations. This schedule was important as it was the input of the simulation model, through the Create block. The company provided the researcher with the schedule of the Thursday Night, Friday Morning, Friday Afternoon, Friday Night and Saturday Morning schedule of trucks arrival for 20 typical days. The schedule that was used in the model occurred by the combination of the schedules of the different days for each shift and the extraction of a representative schedule. This was feasible owing to the small changes that occurred among the same days and shifts in the program. These shifts were selected because they represent the four different types of workloads during a week. Specifically, the typical morning and afternoon shifts (all days of the week) normally operate without delays, the typical evening shifts (all nights except Mondays and Thursdays) have small delays that the next morning shift should indirectly confront, and the typical peak evening shifts (Mondays and Thursdays which have about the same delays) have big delays in loading which are consequently transferred to the next morning shift. In addition, it was selected for the shifts to be consecutive in order to examine the effect of the previous to the next.

- The company utilizes 10 loading positions in morning shifts, 10 in afternoon shifts and 14 in night shifts. The number of morning loading positions could be actually smaller, based on the morning workload, but the morning shift loaders need to load trucks which had to be loaded in the night shift. Thus, the morning shift covers the lack of capacity of the night shift.
- In the morning shift the loadings are quicker, as the majority of trucks are 18-pallet. In contrast, in the afternoon and especially in the night shift many 33-pallet and 35-pallet trucks are loaded.
- The loading position for each truck is predetermined by the plan. The plan is usually followed in the morning and afternoon shifts. However, in the night shifts there is a big number of trucks to be loaded and long delays (particularly in the peak nights) occur for trucks waiting for loading. For this reason, the planned loading position is often bypassed, and the trucks are redirected to the first loading position that is empty.
- The time that is needed for the setup of the loading process (the loader gets the loading order, the truck parks in the ramp, the door of truck opens, the ramp is put on truck), of each truck was measured to be about seven minutes (with a minimum of five minutes and a maximum of 10 minutes). The time that is needed for a truck to depart from a loading position (signing of the loading documents, lifting of the ramp, closing of the truck door, departure of truck) was measured at five to eight minutes, with an average of six minutes. So, the average sum of setup and departure time was measured at 13 minutes most of the times, with a minimum of 10 minutes and a maximum of 18 minutes. The maximum time includes the cases where the truck needs to move to another ramp for loading.
- The time needed for the loading of each pallet (including the scanning activities) was measured to be 90 seconds with a standard deviation of 10 seconds, depending on the performance of the loader.
- Not all the trucks depart from the DC full. Specifically, the company tries to achieve a fulness of 90% for each truck that leaves the DC. This information was used in the simulation model for better depiction of the reality.

Both models (**Figures 5.23, 5.24**) consist of the same blocks. Initially, it consists of seven Create blocks for the seven different trucks capacities that are loaded. The Create block feeds the model with items (trucks) according to a determined schedule. For the assignment of the pallets capacity of each truck generated by the Create block, the Set block was used directly after the generation of the truck. The item (truck) that passes through the Set block takes a value which is determined by the Random Number block. This value transforms the truck-item to pallet-items based on the number of pallets that is going to be loaded in this specific truck. The number of pallets that is assigned to trucks is determined by possibilities which were provided by the company. For example, a 33-pallet truck, according to the recorded data, has a 0.65 probability to be fully loaded, a 0.15 probability to be loaded with 32 pallets and a probability of 0.1 for 31 and 30 pallets to be loaded.

After this procedure, the created items (pallets) are batched again into truck-items, through the Batch block, after they have received the information of their pallets' capacity. The truck-items are then directed, through the Select Out block, in the loading positions. The allocation is sequential and has given the system the order to direct the trucks to free positions first. Before the loading positions, there are Activity blocks which are used to accumulatively simulate the setup and departure time of trucks in order to be added to the total time. These blocks have been set to follow the triangular distribution with a maximum of 18 minutes, a minimum of 10 minutes and most likely value of 13 minutes. This time, in practice, was measured to have no differences among different trucks categories. After these Activity blocks, the truck-item is unbatched to pallet-items, according to its initial pallet assignment and directed to the Activity block of the loading positions. The time that has been set for the loading of each pallet follows the normal distribution, according to the measurements, with a mean of 90 seconds and a standard deviation of 10 seconds.

In addition, in the simulation model, the special characteristics of the reality were taken under consideration. The first characteristic is that the night shift occupies 14 loading positions and the morning and afternoon shift occupy 10 loaders. For this reason, a Shift block was used in combination with Activity blocks (with zero delays) in order to cut the flow in four loading positions during the morning and afternoon shifts. Furthermore, the same technique was used in order to cut out loading positions for a specific time in the morning shift, which should complete the loadings left from the previous night shift and, as a result, the trucks that were assigned to them for the morning loadings cannot be loaded. In these positions, a queue of trucks is created for a specific time which is also measured by the model. The crucial question was how to know which loading positions should be blocked in the model during the morning and afternoon shifts and which loading positions and for how long should be blocked for the simulation of the blocking of the morning shifts due to the delays of the night loadings. To answer this question, the shifts were modeled in separate models, apart from the total model, for both before and after situations. From the separate models, it was inferred that there were no delays in morning and afternoon shifts, but there were in the night shifts. Specifically, for the AS-IS process, in the Friday night 0.9 hours more were needed than the time of the completion of the shift for the full loading of pallets, and in the peak night shift of Thursday, about 1.9 hours more were needed than the time of the completion of the shift. From the 14 loading positions occupied in the night shift of Thursday, 10 of them remained empty or with very low queue of pallets to be loaded. Thus, four empties were selected to be inactivated for the next shifts. Four of the loading positions had still a large length of queue to be loaded after the finish of the shift. It was measured by the model that two of them got empty after 0.7 hours of the shift completion and the other two after 1.9 hours of the shift completion. Thus, for this time period after the completion of this shift, the model was set to block the specific loading positions. The same pattern was followed for the Friday night shift. The difference was that only two loading positions were still occupied after the shift completion for 0.9 hours. These positions were set also as inactive to accept trucks in the total model for this amount of time. In the TO-BE model, where the time of pallets loading was set to a mean of 65 seconds and a standard deviation of 10 seconds after the improvement of scanning activity, it was observed that again four loading positions after the Thursday night shift completion remain occupied, two of them for 0.4 hours and the other two for 1 hour. In the Friday night shift of the TO-BE model, two positions remain occupied for 0.4 hours after the shift completion. These data were used in order to find out the number of trucks of the AS-IS and TO-BE model, that normally had to be loaded in these positions, but are blocked by the delays of the previous shift and create a queue. The company may redirect a small number of trucks in other unblocked loading positions if they are instantly unplanned for morning loading orders; however, this is difficult, as the morning shift starts with a big number of trucks that should be loaded for the morning replenishment of the stores. Moreover, in the simulation, the maximum queue that is formed, without taking under consideration the very small possibility of redirection in other positions, was considered significant to be examined.

The TO-BE model has one more different characteristic than the AS-IS model. The reduction of the loading times in the morning and afternoon shifts, which have no delays problems, can lead to the utilization of fewer loaders. For the decision of how many loaders can be removed, several different scenarios were tested through the simulation model. The testing of the scenarios occurred in the models that were made for each shift separately. The night shifts were not involved in the scenarios, as there were still delays, reduced though, after the improvement (short delays in the Friday night and longer in the Thursday night). The running of the Friday morning shift showed that the system needs 7.5 hours to be empty with 10 loaders. After the reduction of the loading time per pallet, the system with 8 loaders needed the same time. The further reduction of loaders led to the increase of the time that the system needed to empty reached the 8 hours. Thus, the reduction of loaders by two was feasible. The same scenarios pattern was followed for Friday afternoon shift and Saturday morning shift. In particular, in Friday afternoon the time needed for the system to empty was 7.9 hours. With the reduction of loading time per pallet and the removal of two loading positions the system not only remained under 8 hours, but it was also emptied at 7.8 hours instead of 7.9. However, the further removal of loaders led to the excess of the working 8 hours. So, two loaders could be removed from the afternoon shift, as well. In Saturday morning the 7.7 hours that the system needed to empty was reduced to 7.6 after the loaders reduction by two and the reduction of the loading time. Hence, it was decided to remove two loaders from the morning shift and two loaders from the afternoon shift. As a result, the TO-BE model was programmed to cut out six loading positions in the morning and afternoon shifts instead of four in the AS-IS. These positions were again checked to be empty after the completion of the night shifts.

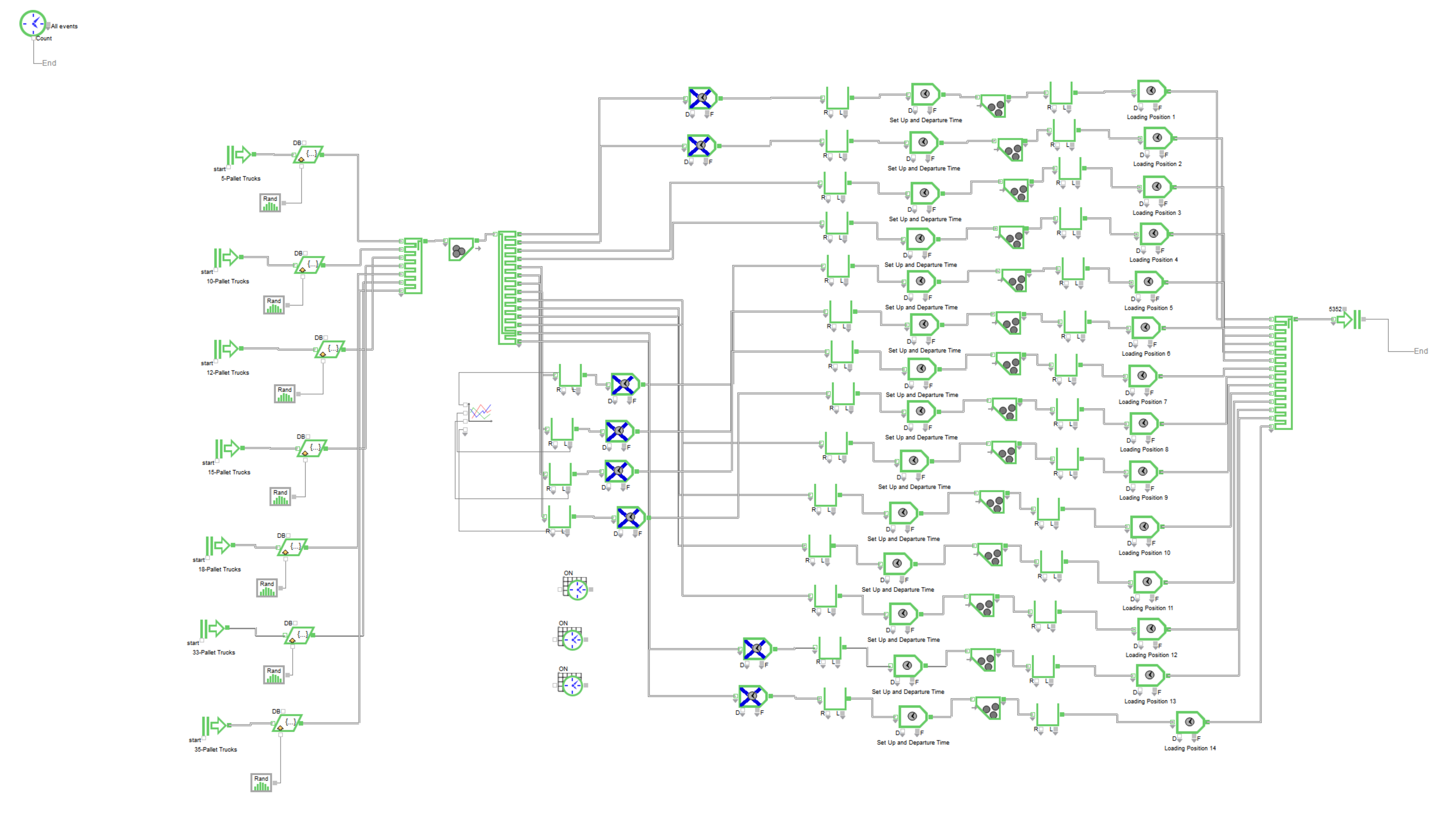


Figure 5.23. Simulation model of the "before" process

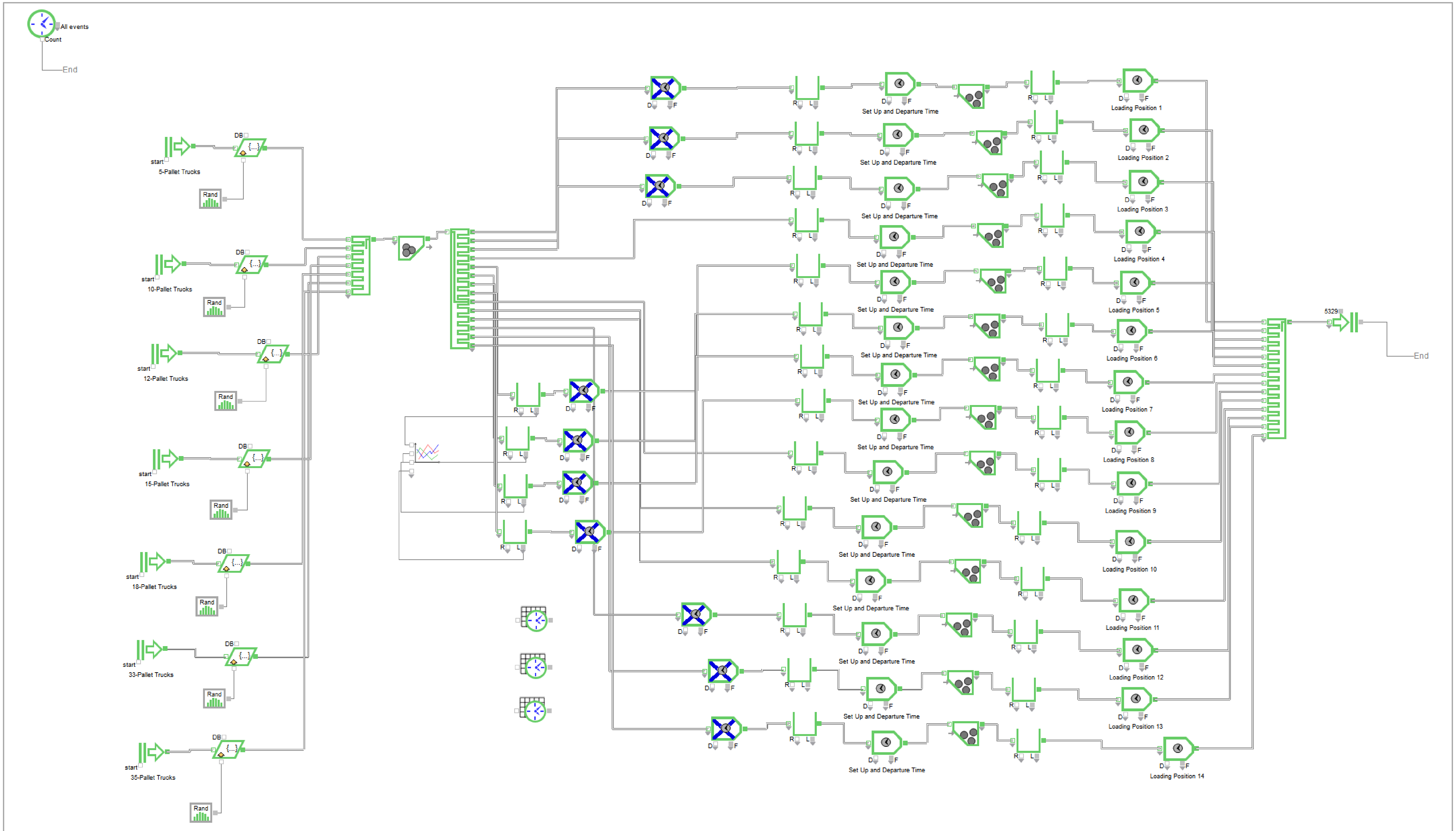


Figure 5.24. Simulation model of the "after" process

After the configuration, all the models were set to execute 100 simulation runs. The simulation runs were selected in order to be sure that the models will give the right results (Law and McComas, 1990; and Hoad et al., 2010). The mean of the time of total delays, as well as the time of total delays of each run, for all the simulation models (each shift separately and the total model with all the shifts) were within the 95% Confidence Interval (that was taken under consideration for this simulation model) limits. Hence, the 100 replications are adequate for the assurance of the reliability of the model. The results of the runs were:

- As already mentioned, in the **AS-IS model** of the peak night shift (Thursday night) there is an average delay of 1.4 hours (minimum 0.9 hours, maximum 1.9 hours) per truck to be loaded, after the beginning of the queue creation, and 1.9 hours needed after the completion of the shift for the emptying of the system. These delays were transferred to the morning shift for the completion of the loading tasks. The company confirmed that in the real world, indeed the delays of merchandise loading in peak night shift can reach the two hours. So, the model is confirmed by the reality. The result of these delays was that a queue with a median of 10 and a maximum of 13 trucks was formed in the morning shift due to the loadings left unexecuted because of the workload of the peak night shift, as shown in **Figure 5.25**, which occupied two of the 10 loading positions of the morning shifts for up to 0.87 hours and two more for up to 1.89 hours.
- After the insertion of the RFID, the **TO-BE model** results in an essential improvement in the delays of the loading process. In the peak night shift, the average of the delays that were recorded was 0.7 hours (minimum 0.4 hours, maximum 1 hour) per truck and 1 hour was needed for the emptying of the system for two occupied loading positions. The queue of trucks that is created in the morning shifts for loading, due to the delays of the night shifts in these two loading positions, has a median of four trucks in total and reaches the maximum of five trucks, in the Friday morning shift (after peak night), as shown in **Figure 5.26**. In the TO-BE model the reduction of loading positions from 10 to 8 in the morning and afternoon shifts, based on the RFID insertion, did not affect the system with delays and the shifts were finishing their activities during the 8-hour margin. So, the reduction of loaders can be successfully implemented. In addition, in the TO-BE model a 5.4% reduction of loading positions processing time was achieved compared to the AS-IS model.

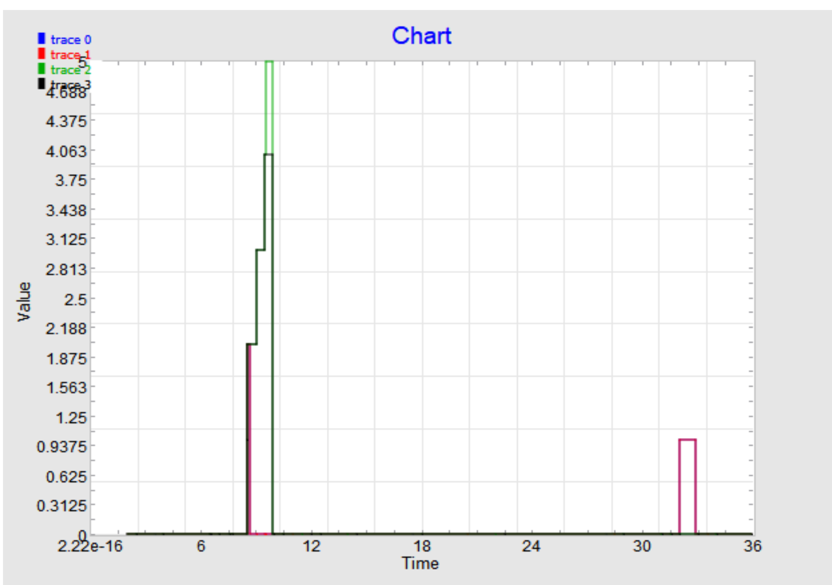


Figure 5.25. Line chart of the maximum length of the queue formed by the trucks that are blocked in the morning due to the delays of the night shift for the AS-IS model

Cost-Benefit Analysis

The introduction of the RFID technology, though, needs an investment which should be evaluated in order to infer whether it is profitable. The first thing that was calculated was the cost of the investment. Market research was conducted in order to specify the cost of the equipment and the software that was required for Mandra 1 DC. In this research, the cost of the annual required consumables (RFID labels) and the annual maintenance costs for the equipment (problems that should be fixed) and software (licenses and potential updates) was also taken under consideration. The total cost of the initial investment was about 455,000 **€** and a cost of 110,000 **€** for consumables and maintenance is required, as shown in **Table 5.3**.

Table 5.3.Cost calculation for the RFID investment

Cost Category	Cost (€)	Cost after the initial investment/year (€)
RFID labels (for the first year)	75,000	75,000
RFID printers	10,000	
RFID fixed readers, antennas, mounts and cables (plus installation) (for all 35 gates)	190,000	
Middleware and Software	180,000	
Maintenance		40,000
Total	**455,000**	**115,000**

For the evaluation of the investment NPV was used along with IRR. The financial benefit of the improvement action is calculated by the reduction of manhours per day owing to the quicker scanning through RFID and by the reduction of errors occurring that led to the non-loading of approximately 15 pallets per day, resulting in out-of-stock in stores. Specifically, the financial benefit is:

Man-hours Reduction

By reducing approximately 25 seconds, for each pallet loading utilizing RFID technology, the simulation models showed that four loaders can be removed, two from the morning shift and two from the afternoon shift. Even if the simulation models concern specific days of the week, this inference can be generalized according to the measurement of the company about the morning and afternoon shifts of the rest of the week in Mandra 1, which are completed at about the same time. Thus, 32 man-hours can be saved per day. By multiplying the 32 man-hours/day with 330 days (the working days of the DC), the result is that 10,560 hours fewer are required. The average cost per manhour is 7€. So, the total cost reduction owing to less man-hours is **73,920€/year** (10,560*7).

Out-of-Stock Reduction

The out-of-stock of products in stores that have been reported during a year, due to all the reasons, was calculated that could lead to a 2% of revenue increase. From this percentage, the 0.2% has been measured to be due to the loading errors of non-loading of pallets in Mandra 1, resulting in the non-availability of products in stores, on time needed. The company has a revenue of about 2 billion euros per year. Multiplying these earnings by 0.2%, the revenue increase of the out-of-stock reduction owing to the elimination of errors is **4 million €/year**. The average net profit of the company was calculated by the

Department of Finance at 4% of the revenue. Consequently, the retailer could increase its net profit by **160,000 €/year.**

Cost-Benefit Analysis/ Total Financial Benefit

In the two figures which were calculated in the previous two paragraphs, the cost of the consumables for the operation of the RF scanners in Mandra 1 should be added, as the company will no longer have to buy barcodes for the DC. The cost was estimated to about **15,000€**. In addition, for the calculation of the total financial benefit the cost of the maintenance and the consumables of the RFID system have to be taken under consideration, which were estimated at **115,000€/year**.

Hence, the ***total financial benefit*** of the insertion of RFID in the Mandra 1 DC is ***133,920€/year***.

The evaluation of the investment began with the payback period of the investment which is:

$$\boldsymbol{Payback\ Period} = \frac{455{,}000}{133{,}920} = \mathbf{3.39}\ \boldsymbol{years}$$

The result means that, in less than three and a half years, the RFID investment will be paid back. The PV of the investment was decided to be calculated for seven years, as this time period is between the 5-10 year-time period that is generally considered as the useful life for equipment (Ernst and Young, 2016). The discount rate that was used and suggested by the company in its investment appraisal was 15%. This is the rate that could be achieved by the company selecting alternative investment initiatives, calculated by the Department of Finance. Thus, the rate of 0.15 was used for the estimation of the PV. The PV was calculated with the formula:

$$\boldsymbol{NPV} = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t} = \frac{133{,}920}{1+0.15} + \frac{133{,}920}{(1+0.15)^2} + \cdots + \frac{133{,}920}{(1+0.15)^7} - 455{,}000 = \mathbf{102,163}€$$

The value is positive, so the investment is accepted.

The **IRR** -that makes PV equals to zero- of the investment was calculated though Excel and its value was **22.199%**, for the seven-year period. The IRR is higher than the 15% rate that was set by the company, so the investment in RFID is shown to be efficient, based on the standards set by the company.

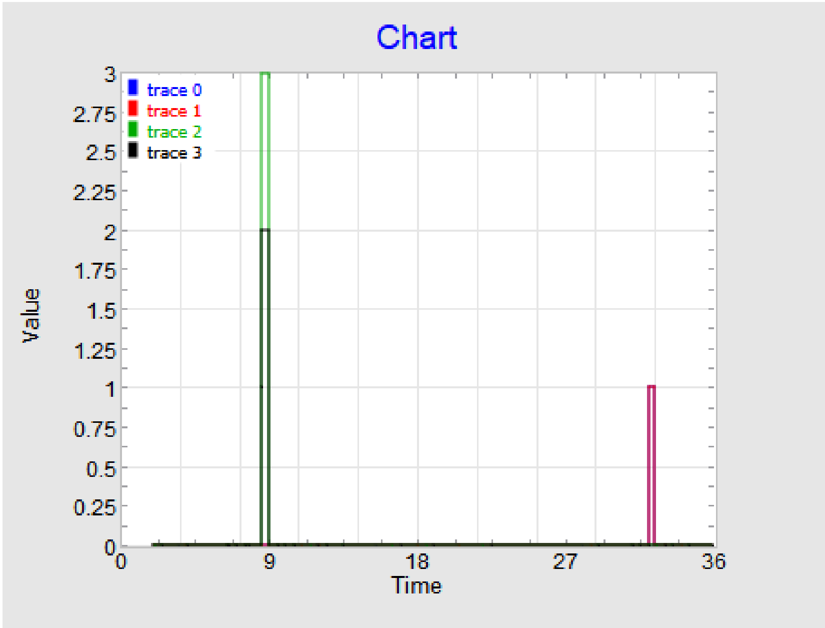


Figure 5.26. Line chart of the maximum length of the queue formed by the trucks that are blocked in the morning due to the delays of the night shift for the TO-BE model

For the typical “closure”/completion of the project, the results of the improvements were presented to all project stakeholders and to the top management in order to document the changes needed and to inculcate the usefulness of LSS adoption for future CI initiatives. The positive results that were presented to the top management led to the decision of extending this LSS pilot project to more departments and processes and to the multiplication of CI initiatives. The company also understood that the training of its employees for sustaining the mentality of LSS and further implementing LSS projects is very important and that, from a series of small LSS initiatives, cumulative significant benefits can be attained.

5.4 Results and Conclusions of the Case Study

The inferences extracted by the case study concern the benefits that the company attained via the implementation of an LSS initiative based on the proposed LSS RSCPR, and the CSFs that played a crucial role in the successful conduction of the project. In addition to the CSFs, there were limitations for the successful conduction of the project regarding the available data which managed to be confronted.

The first benefit of the improvement in loading process is the reduction of the errors that occurred because of the tiresome scanning activity with the barcode scanner. This positive change is following the principles of lean concerning errors reduction and leads to the elimination of the approximately 0.2% of out-of-stock products in stores.

The second benefit is the reduction of the loading time of pallets by 27.8%, and as a result of loading orders lead time, which led to an essential decrease of delays, particularly in the peak night shift, where the problem was mainly detected. The simulation model indicated that the maximum delays of the peak night shifts that resulted in the loading of the trucks by the morning shift, blocking a percentage of its capacity for a specific time, were reduced by 52.6%. In addition, the trucks that have left by the peak night shift to be loaded in the morning shift block in the TO-BE model occupied only two loading positions in comparison with the four loading positions blocked in the AS-IS model. This was also depicted in the reduction, of 61.5%, of the queue of trucks coming from the peak night shift for their loading in the morning shift.

Hence, the adoption of RFID technological solution leads to the reduction of the process steps making it simpler and faster, as lean principles require. The financial benefit of this investment is a consequence of both the reduction of the loading time, which requires less active loading positions, and the confrontation of the faults that led to a percentage of out-of-stock merchandise, which caused a loss of earnings that is now covered.

For the attainment of these benefits and the success of the LSS initiative in the loading process of the retailer of the case study, the fulfilment of a series of CSFs was important. The first CSF that essentially determines the acceptance of the LSS initiative and the unhindered completion of the project was the participation of both the top and middle-level management team of the Department of Logistics of the company. The continuous communication and meeting with the managers and directors of the Department led to the detection of the problems of the loading process and the identification of the need for an improvement in it. In addition to the significance of the involvement of top and middle-level management, the active involvement of loading employees and their cooperation with the management team, made them understand the importance of their contribution to gather the data and to find solutions for the problems of the process. This involvement of employees in the LSS project help them develop a spirit of collaboration and comprehend the benefits that CI brings to their work.

The active participation of the management team in this LSS initiative not only facilitated the conduction of the project, but it also led them to understand the CI mentality in general, and that its incorporation into the strategic goals of the company is very important. The reason for this decision was the realization of the significance of a consistent program of projects, incorporating LSS (after the training of the employees) or other CI methodologies, in order to achieve gradual and cumulative improvement and benefits in the company's operations.

Finally, this pilot project in Mandra 1 constituted the pillar and the starting point for an upgrade of technological solutions that are utilized in the supply chain of the company, such as the penetration of RFID in more processes, the adoption of more advanced technologies like autonomous or AR loading and picking/packing, the implementation of IoT in various processes of the supply chain, and the upgrading of information systems utilizing advanced algorithms for forecasting, replenishment and routing, and supporting collaboration amongst the stakeholders of the supply chain. The contribution of LSS can be determinant for the accomplishment of the technological upgrade, as it offers a wide toolset for identification of problems, and measurement and analysis of the data which can facilitate the selection of the appropriate investments for the improvement of business processes.

Although the LSS project was successful and led to the implementation of an LSS initiative according to the LSS RSCPR, an important problem occurred in the beginning of the LSS project and that was the limited access to data. Two reasons contributed to this lack of available data. The first one was that the company itself was not measuring, in a systematic way, all data categories that could be useful for the analysis of the loading process and its connection to other processes. There were also occasions that the data provided by the company in specific activities of the process were empirical and approximate, and not based on long-term measurements. Hence, they were not appropriate for statistical analyses. In addition, the Logistics Department was separated in sectors that did not have neither the right communication nor an established canal for data sharing. The second reason was that the company was not fully open in sharing all the data needed for the analysis with the researcher. Even if the management team was positive and helped in the conduction of the project, a strict policy of confident data about the processes did not permit the collection or the provision of extensive time-series of data. Thus, the analysis of the LSS initiative was based on the measurements of the researcher, in order to confirm empirical data and collect more information, and on the specific information and limited data provided by the company. Supplementary to the strict data sharing policy, the collection of appropriate data was also difficult because the company has not had any previous experience of LSS or CI projects implementation, and many of the employees and managers were not familiar with the notion and principles of lean and LSS.

Nevertheless, even if there was a limited data availability in the beginning, the LSS project and the LSS RSCPR in general, that aroused the interest of the Directors of the Logistics Department in order to detect the operations problems, managed to be implemented owing to the gradual and continuous gathering of data during the project duration. Furthermore, this LSS initiative achieved to combine data from two sectors of Logistics Department, the transportation and planning sector. Finally, despite the fact that the company did not reveal all the business rules of its operation, particularly in planning, the researcher tried, with the synthesis of the provided data and the observations during the Gemba walks (the action of going to see how the actual process works) in the logistics, which is a basic principle of lean in order to understand the process, to configure the best possible picture of the loading process.

5.5 Case Study Validation

The case study analysis demonstrated a full LSS implementation, based on the LSS RSCPR directions, in a retail company which participated in the development of the reference model. However, the correctness and quality of the case study should be checked in terms of construct validity, external validity and reliability which are the criteria for descriptive case studies according to Yin (2009). Construct validity has been achieved by gathering both real-time and archived data by the company in order to conduct the project and confirm the statement of the need for change. The results of the changes were evaluated by the Department of Logistics employees and managers contributing to construct validity, too. External validity has been achieved by interpreting the results of the case study which revealed that the benefits described in theory are indeed the outcome of an LSS application, following the steps of the LSS RSCPR in a major retailer. Through the case study, it was also revealed that the fulfillment of CSFs is crucial for the completion of LSS projects in manufacturing companies and should always be taken under consideration, confirming the theory. Reliability has been achieved through the design and implementation of the DMAIC methodology and by using selected tools and techniques for data collection and analysis from its toolset. In particular, the data collection procedure followed helped in the development of a database of data for the analysis of before and after improvement situation and the analysis was conducted using tools for the best elaboration of data. Hence, the study was set up in order to be able to be repeated with similar results. In fact, this was an important contribution of the presented case to the company under discussion.

6 Conclusions and Further Research

6.1 Theoretical Implications

The construction of the LSS RSCPR, as a first reference model proposed in the literature that includes the connection between specific activities of the retail supply chain with the LSS methodology, contributes to the configuration of a general framework which aims to fill a detected gap in the literature. The developed model utilizes a complete architecture (ARIS), encompassing several views in order to describe, with as much detail as possible, the empirical information and data that were collected by the companies that participated in its configuration. The way that the model was decided to be developed offers a detailed and spherical view of the supply chain operation of the retail organizations. As a result, the LSS RSCPR connects all the aspects of the retail supply chain with targeted LSS projects and improvements which aim at the confrontation and the healing of the defined pain points with the steps presented in **Figure 6.1**. In addition, it indicates that the LSS tools is the most important part of the DMAIC method for the conduction of the projects, and for this reason a separate diagram of proposed tools is provided. A great emphasis is given to the combination of qualitative and quantitative tools, as shown by the tools selection, as for an LSS project, the best possible justification of the reasons that lead to the improvements is needed.

Finally, the connection between the technological trends of the retail supply chain and the implementation of LSS initiatives is attempted for the first time, and it can help in the fulfillment of LSS principles. For example, the introduction of automations, IoT technology, and technological solutions in general, which are part of Industry 4.0 (Panayiotou et al., 2020), along with information systems/ collaborative platforms and advanced algorithms, were considered to be necessary for the enhancement of visibility, supply chain collaboration and improved efficiency, effectiveness, and responsiveness. Lean supply chain practices and Industry 4.0 are positively linked and enhance the efficiency of processes (Marodin et al., 2017; Tortorella, Miorando, and Marodin, 2017). Industry 4.0 principles have the ability to facilitate the adoption of Lean practices throughout the entire Supply Chain (Tortorella and Fettermann, 2018; Rossini et al., 2019; Tortorella, Miorando, and Cawley, 2019) and to support the improvement process (Sanders, Elangeswaran, and Wulfsberg, 2016; Pinho and Mendes, 2017; Buer, Strandhagen, and Chan, 2018; Rossini et al., 2019), as it happens with RFID technology, that can contribute to JIT replenishment (Sellitto et al., 2007).

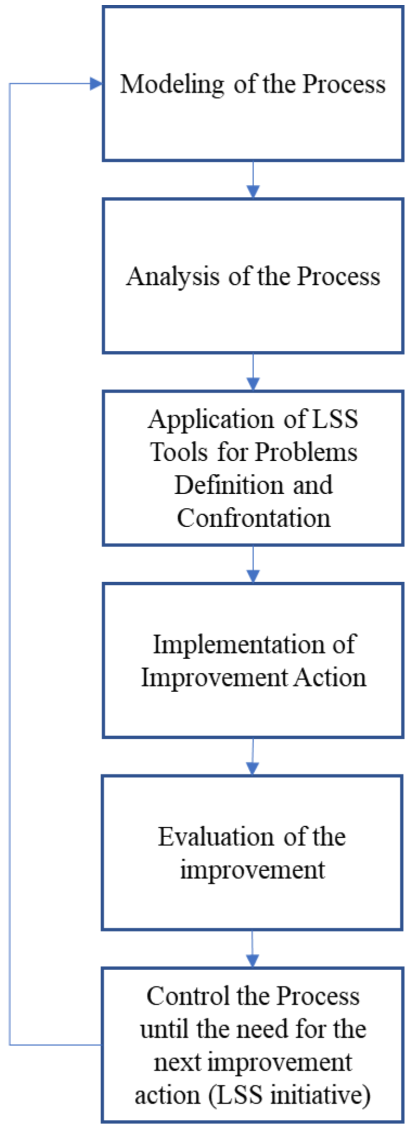


Figure 6.1. Implementation phases of LSS RSCPR

6.2 Managerial Implications

The first implication of the adoption of the LSS RSCPR by the companies in practice, is the understanding of the whole flow of the supply chain and the confrontation of complex problems that need the cooperation of more than one department in order to find a possible solution and implement improvement actions. The reference model also offers necessary information to practitioners for the implementation of the appropriate LSS projects which will lead to the improvements. Specifically, the instructions describing the steps of DMAIC that should be followed and the proposal of tools, to which an emphasis could be given for the conduction of the projects, can support the retail sector, which, as shown by the literature, lacks the necessary experience in the adoption of LSS.

Thus, the model presents the guidelines and the data that should be gathered for the selection of the best improvement actions. An emphasis in contemporary technological trends, apart from the managerial changes, has been given as this was decided to be of great importance by the participating companies of this study. For this reason, the technological solutions that can be utilized as LSS initiatives can lead to gradual improvements, which will result in a cumulative high-positive impact, fulfilling the principles of CI. These technological solutions, which are an imperative need for the retail sector and follow the world best practices, are Industry 4.0 and IoT (Facchini et al., 2020, Núñez-Merino et al., 2020), information and collaborative systems (Hove-Sibanda and Pooe, 2018), AR (Moorhouse et al., 2017), RFID and advanced algorithms (Ge et al., 2019).

The rational of the model is to encourage companies of the retail sector to modernize the operation of their supply chain and to build a relationship between the processes. For example, the communication between forecasting and replenishment-related methods can lead to more accurate orders and less stock-outs or excessive stock. The existence of transparency among the stakeholders of the supply chain (vendor, retailer, and possibly reverse logistics retailer) can lead to a collaboration which can enhance the JIT replenishment and help reduce waste and costs. The communication among picking/ packing, loading and distribution-related processes can facilitate the flow and the operation of the warehouse and lower storage and administrative cost. For the attainment of these correlations, the insertion of the appropriate information systems/ collaborative platforms and IoT/ automations technological solutions is necessary.

Hence, the improvement actions that are proposed by the LSS RSCPR are scalable and can be adopted gradually by the retailers in order to get prepared and smoothly make all the appropriate changes for the improvement of their processes. The structure of the LSS RSCPR, where the LSS initiatives refer to improvement areas of specific supply chain activities, enables gradual adoption of changes based on the specific priorities set by each retail company. The prioritization of the LSS initiatives depends on the strategic orientation of each company, regarding its supply chain and its commercial performance, and on the capabilities and the availability of the necessary resources. The level of a company in terms of technology utilization (information systems, algorithms, automations) and the physical operation of its warehouses, as well as the investment margin, are the decisive factors which will determine the LSS initiatives that will be selected. In this way, each LSS initiative can be succeeded by more LSS initiatives through all supply chain processes and each improvement leads to more improvements following the mentality of CI.

The LSS initiatives included in the reference model can contribute to the achievement of stock reduction, improved and advanced execution of logistics and store processes, decrease of faults and optimization of merchandise purchasing, management, distribution and selling resulting in reduced cost and increased profits. In addition, the reduction of time needed for the completion of processes and the transportation of merchandise, as well as the support of decision, help activities to be leaner. Moreover, supply chain stakeholders can establish strong communication channels and the adoption of JIT and “pull” principles can be facilitated owing to the transparency and the continuous recording of all supply chain moves along with merchandise stock and transfers.

The validation of the implementation of LSS RSCPR through the case study in a major retailer of Greece was very useful for its evaluation. This case study revealed all the aspects that are needed for the successful implementation of LSS in the retail supply chain. The rigorous and guiding nature of DMAIC method facilitated the detection of the problems and the collection and analysis of the data. The wide range of tools that LSS includes led to the selection of the most suitable according to the needs of the project. The correlation of specific improvement actions with specific activities of the modeled processes simplified the procedure of selecting the appropriate solution for improving the loading process, which was studied in this case. In addition, the real benefits that the company attained by the application of LSS initiatives were recorded, through the application of the model, and the positive results of the simulation and the cost-benefit analysis in the Improve phase confirmed that the model can be effective if it will be used in the structured way that it has been presented and described. Finally, the case study pointed out the significance of the fulfillment of the CSFs for the conduction of LSS projects which is connected with the adoption of CI mentality by companies, as well. It was apparent that the fulfillment of mainly two factors -the involvement of management team and employees and their collaboration, and the incorporation of CI in the strategy of the company with the intention for more LSS projects conduction- led to the success of the LSS initiative adoption. The results of this case are very encouraging and indicate that the LSS RSCPR can be extensively implemented by the company for the improvement of more processes and can be adapted to the needs of organizations owing to its encompassing of a wide range of LSS initiatives/improvement actions.

6.3 General Conclusions

Following the principles and the methodology of empirical research after the detection of the research gap, this study developed a reference model which can be utilized by retail companies desiring to integrate CI mentality in their supply chain processes by adopting LSS initiatives. The LSS RSCPR constitutes a framework that has been configured by recording retail supply chain processes with the contribution of two case companies, existing theory on the field, and best practices. The processes that were modeled in LSS RSCPR cover important aspects needed for the understanding of the retail supply chain and were crucial for the identification of the activities that can be improved through LSS implementation.

The identification of LSS improvement areas as a first step to recognize candidate LSS initiatives is a method that can facilitate the adoption of LSS through the provision of a better visibility of the problems, which can or must be confronted. The facilitation of the retail companies to recognize and implement the appropriate LSS initiatives in their supply chain processes is also enhanced by the proposals of the reference model and the instructions on how to follow the DMAIC phases. The supplementary repository of selected LSS tools, which can be utilized for the application of DMAIC, completes the reference model in order to cover all the necessary aspects of the improvement roadmap. Hence, the LSS RSCPR can be characterized as a complete guide that can reinforce the efforts of LSS adoption.

The identification and analysis of the supply chain processes of the retail sector through the two participating companies helped in the good understanding of the operation of the supply chain and the recognition of typical pain points. The improvement suggestions of these pain points through the adoption of proposed LSS initiatives were based on the introduction of contemporary technological solutions, the utilization of related information technology, the application of advanced algorithms, and the adoption of lean management practices.

In conclusion, the LSS RSCPR model that is presented in this doctoral dissertation manages to answer the two crucial research questions:

1. *What retail supply chain activities are eligible to be improved with the help of LSS methodology?*
2. *How can LSS contribute to the improvement of retail supply chain processes?*

The answer to the first question comes with the modeling of the typical business processes and activities of the supply chain of companies operating in the retail sector, and from these, by identifying the activities that can be substantially improved by LSS initiatives. The second question is answered with the suggestion of several LSS initiatives that can be implemented in the identified candidate activities for improvement, as well as, with the description of the process of implementing the initiatives, and with the suggestion of the tools from the DMAIC method that can be utilized. In this way, the proposed reference model fills the research gap recognized in the literature review, contributing to the academic society. At the same time, it contributes to the practitioners working in the supply chains of companies operating in the retail sector, by providing a structured model that can assist them in their CI pursuits. The suggested reference model helps overcome barriers that prevent the adoption of LSS in the retail supply chain, by providing LSS knowledge connected to the real-life processes, indicating areas for future training effort, highlighting areas appropriate for the introduction of technological solutions, supporting information sharing between all partners through the whole supply chain, building executive commitment in CI, reducing the resistance to change, and providing assistance in management strategic decision making.

The successful implementation of a part of the LSS RSCPR in the company of the case study, after the confrontation of the barriers, shows that LSS can contribute to the improvement of retail supply chain process, and the loading process in this case. Specifically, as an additional answer to the second question, it was observed, during the case and the interaction with the company, that LSS acted as a guiding framework to support the needs of the company for improvements. In particular, the steps of the DMAIC method facilitated the procedure of detecting problems, collecting, and analyzing data. It showed a path for the structured implementation of improvements by organizing the thinking and the actions of the project participants in order to end up with a solution to cope with the operational problems. The utilization of LSS tools managed to compose the whole picture of the process that was selected for improvement, as they achieved to gather and analyze the necessary data combined with the implicit knowledge of the management team and employees. Hence, the case study indicated that LSS tools and DMAIC can constitute a guide for the retailers in order to be led to the appropriate improvement actions according to their operational problems and even detect (previously undetected) problems in specific operational areas, processes or activities that their confrontation, with the gradual adoption of simple to more sophisticated solutions, can bring several significant benefits.

Moreover, the importance of the systematic and systemic recording of data in order to be easily accessible and ready for elaboration was revealed by the case study. It was difficult for the employees to collect the necessary and accurate data (raw data without estimations) for the facilitation of the LSS initiative implementation. For this reason, a significant inference that was extracted during the conduction of the LSS project was that there is need for a completed and contemporary information systems infrastructure that will provide the employees with utilizable data in order to improve the processes. The live measurement of specific metrics regarding the process under improvement is important, as well; however, the depiction of the situation and the recognition of the problems can be easier and more rapidly and directly occurred by a systematic, analytical and structured recording of data through integrated information systems. Especially if the company pursues the improvement of its processes through the adoption of LSS initiatives, such as those suggested in the LSS RSCPR, the quick gathering of usable data is of high importance for the right choice about the appropriate improvement action.

Finally, an additional need that should be investigated, which arose by the conduction of the case study, is the better training of the organizations' employees about how the business processes can be recorded and improved. This suggestion concerns the training that the managers and employees of organizations take at a professional or academic level. The lack of the mentality of BPI and CI, that was observed during the implementation of the LSS initiatives, creates problems in the comprehension of the significance of the continuous effort for process improvement and achievement of business goals. It was also observed that the management team spends much of its energy and time in administrative issues without having as a priority neither the full comprehension of all the details of the operations, nor the improvement of processes which can confront many operational issues that occur on a daily basis. Consequently, there is a need for research on how BPI, CI, and even LSS, can be included in complete courses of universities which will teach the interlacement of process improvement and CI, technology, management, and strategy in order to give future managers the opportunity to understand the whole picture of the business environment, not as separated activities (i.e., for example considering operation management and strategy configuration as unrelated areas), and the manner in which the CI, and as a result the LSS, principles are complementary to operations and business strategy, and facilitate the achievement of business goals.

For the achievement of all these goals the university programs should provide some degree of education in LSS, such as within engineering schools, for example. Such education and training in LSS would give graduates an advantage over other candidates who lack training on BPI and CI and its interlacement with business management. This thought is not new; several schools have launched LSS educational efforts. Some schools have been innovative by the early stages of LSS appearance and have added courses in structured improvement efforts in their regular curricula. In the United States, for example, Arizona State, North Carolina State, and Virginia Tech have all introduced LSS-based problem-solving courses to their engineering and statistics programs. (Anderson-Cook et al., 2005). These formal educational programs expanded to many universities of the USA, Europe (especially the UK) and Asia mainly in postgraduate level and as part of courses or independent courses of undergraduate.

Research can be also conducted on how this kind of training could enhance the leadership skills of the operations and organization leaders, not only in the retail sector, but in all sectors. The managers of different levels should understand and undertake the role of leader, as the adoption of CI requires the regular communication amongst the team members and the cooperative detection and confrontation of the needs for improvement, which are identified by the total comprehension of the internal and the external business environment.

For this reason, the LSS and CI education should not be included in the university programs only for the providing of the training about quantitative methods and tools of the methodology, but mainly for the development of the soft skills that the philosophy of LSS and CI leads to. Ideally, project-based courses with real case studies for LSS implementation could help students understand the philosophy of lean and the tools of Six Sigma along with the notion and rationale of business processes. In addition, team projects can teach and gradually improve the communication skills and the management and leadership skills of the students, as diverse team members should cooperate, share ideas, and organize their work, resources and budget in order to improve business processes and operations.

6.4 Further Research

The development of the LSS RSCPR can be the pillar for future research for the penetration of LSS principles in the retail sector. A first area for further research can be the modeling of more processes regarding the retail supply chain and their integration with the existing model. In the reference model that was proposed in this study, despite the fact that it presents the overview of retail supply chain processes, emphasizing more on the logistics processes (receiving, preparing for shipping, distribution of merchandise). This happened since the main interest of improvement and the availability of data by companies concerned logistics operation, which is very important and offers ground for improvement (Fernie and Sparks, 2018). Nevertheless, the more focused study on other parts of retailers' supply chain (e.g. customers value chain), by analyzing other processes in lower level and more detail, could bring more proposals for LSS initiatives. A crucial parameter that should be taken under consideration for the enrichment of the model is that the improvement actions, which will be added for the new processes, should be correlated with the existing proposed management and technological improvements in order to achieve better results.

The second area that is offered for further research is the implementation of the LSS RSCPR in more retail organizations. The model was developed in cooperation with large retailers and its testing was also conducted in a large retailer. Thus, there is a need to check its applicability in SMEs. In this way the model will be evaluated under the specific needs and requirements of companies of different sizes and in different business environments of other countries. The results of more case studies will confirm the universal character of the proposed reference model and will infer its practicality as an organizing and improvement guide. The results of the case study conducted for the validation of the model in this dissertation have already shown their positive impact in the improvement of retail supply chain processes and the acceptance of the LSS RSCPR by the companies, that participated in its configuration, as a guide for their improvement initiatives after its presentation to them is a good sign about its practicality. However, there are always margins for improvement and the multiple case studies could lead to the configuration of upgraded versions of the LSS RSCPR which will include more data that were not available during its initial development.

Finally, a completely new study could be the selection of specific and universally applicable KPIs for the several processes of retail supply chain, based on the literature and on proposals of retail companies according to their empirical data of the real business environment. KPIs regarding sustainability and green impact of operations could be taken under consideration for the controlling of the social and environmental impact of operations, as well. These KPIs, then, can be integrated into the architecture of the model in order to be used as metrics for the evaluation of the improvements that were conducted in the business processes by implementing LSS initiatives. The indicators could be proposed, even in the form of Balanced Scorecards, and can be developed in combination with the strategic KPIs of retail companies in order to evaluate the improvements according to the strategic plan. Thus, LSS could be studied as a methodology of process improvement, which can be connected with the operations and business strategy and fulfill the goals of the company in both strategic and operational level. Consequently, a further extension of the proposed reference model, through a future study, which will need extensive research, could give an even more simplified solution to the retailers.

List of Publications

Scientific Journals:

- Panayiotou, N.A., Stergiou, K.E. (2021), "Development of a Retail Supply Chain Process Reference Model incorporating Lean Six Sigma Initiatives", *International Journal of Lean Six Sigma*, [accepted with revision]

- Panayiotou, N.A., Stergiou, K.E. and Panagiotou, N. (2021), "Using Lean Six Sigma in small and medium-sized enterprises for low-cost/high-effect improvement initiatives: a case study", *International Journal of Quality & Reliability Management*, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/IJQRM-01-2021-0011

- Panayiotou, N.A. and Stergiou, K.E. (2021), "A systematic literature review of lean six sigma adoption in European organizations", *International Journal of Lean Six Sigma*, Vol. 12 No. 2, pp. 264-292. https://doi.org/10.1108/IJLSS-07-2019-0084

- Panayiotou, N.A., Stergiou, K.E. and Chronopoulos, V. (2020), "Implementing a Lean Six Sigma standardized toolset in a manufacturing company: a case study", *International Journal of Productivity and Performance Management*, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/IJPPM-08-2020-0423

International Conferences

- Panayiotou, N. A., Stergiou, K. E., Stavrou, V. P. and Psaltakis, M. N. (2020), "Digital Transformation of the Process of the Connection of New Users in the Natural Gas Network utilizing CRM system and Industry 4.0 technology", *2020 6th International Conference on Mechanical Engineering and Automation Science (ICMEAS)*, pp. 14-18, doi: 10.1109/ICMEAS51739.2020.00010.

- Panayiotou N.A., Stavrou V.P., and Stergiou K.E. (2020), "Identifying Key Business Processes that Can Benefit from Industry 4.0 in the Gas Sector", In: Lalic B., Majstorovic V., Marjanovic U., von Cieminski G., Romero D. (eds) Advances in Production Management Systems. The Path to Digital Transformation and Innovation of Production Management Systems, APMS 2020, IFIP Advances in Information and Communication Technology, vol 591, Springer, Cham.

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Appendix A1.1. Data Dictionary

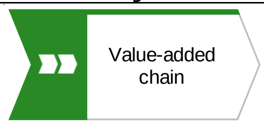
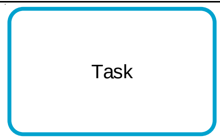
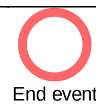
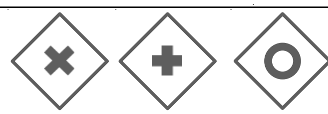
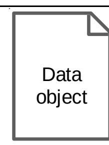
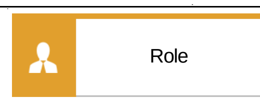
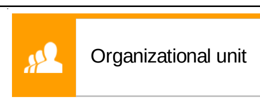
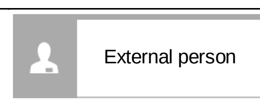
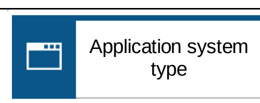
Diagram	Object	Object Description
Value-Added Chain Diagram		Each VAC object relates to a BPMN process
Enterprise BPMN Collaboration Diagram		Depicts the activities that every participant executes in the process
		It is the starting point/ trigger of the process
		It is the end of the process
		Depicts information, data or document sent among process participants during the process
		The first one is the XOR (exclusive) gateway, the second the AND (parallel) gateway, and the third the OR (inclusive) gateway
		Symbolizes the documents shared in specific process steps
Function Allocation Diagram		Represents employees of the company undertaking specific activities
		Represents departments of the company undertaking specific activities
		Represents external participants to the activities (e.g., Vendor)
		Depicts the IS supporting the activities
		Shows the business rules related to activities
		Presents the risks connected with activities

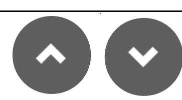
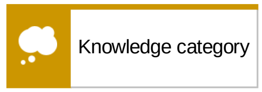
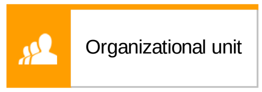
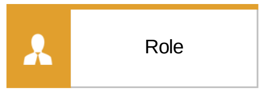
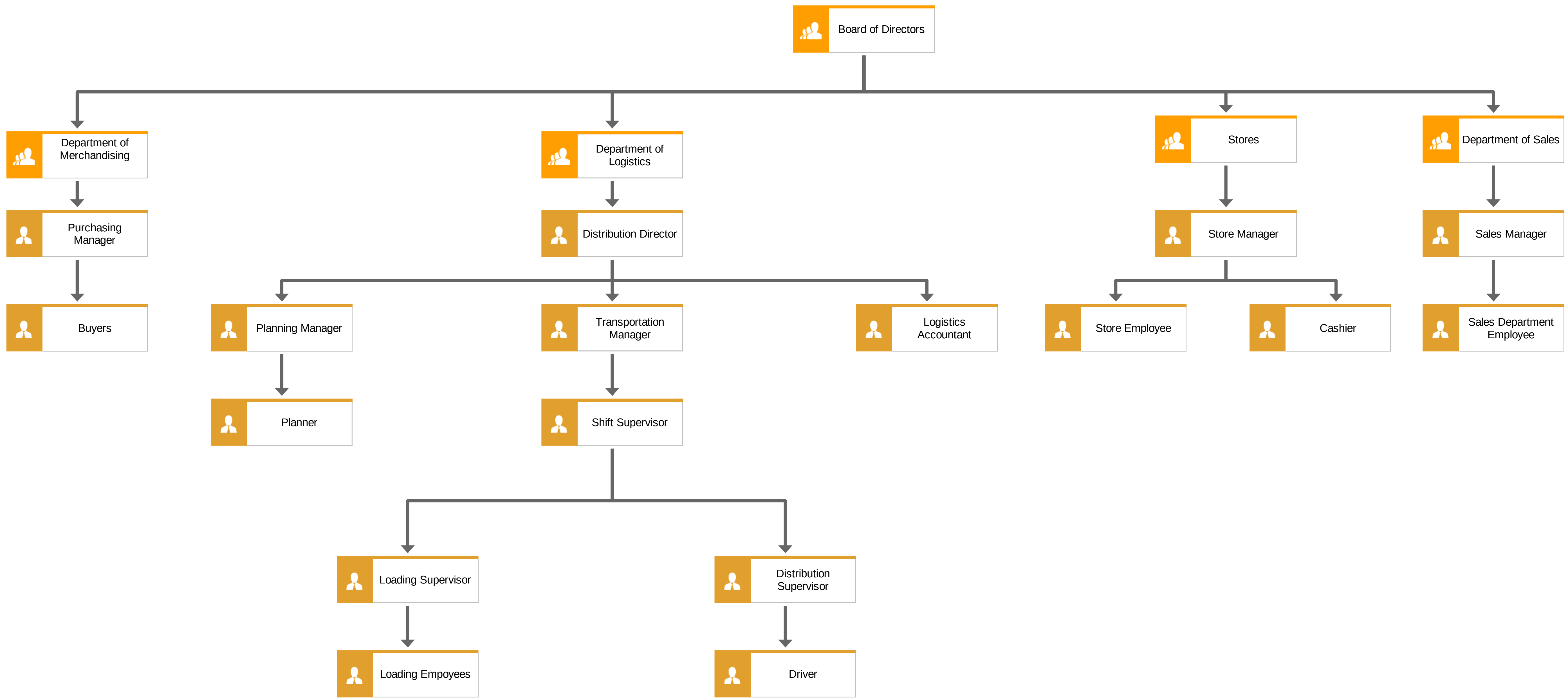
Diagram	Object	Object Description
	Control	Shows how to mitigate risks
	Information element	Represents the information utilized in IS
	KPI instance	Used for the proposed KPIs for the retail supply chain operations
	Warehouse equipment type	Depicts specific equipment and characteristics needed for the completion of activities
	IoT object	Depicts specific equipment sensors needed for the insertion of automations in activities
	Bar code	Represents the bar codes that scanned for the completion of activities
	Electronic folder	Presents the electronic folder of the IS that documents and data are kept
	Electronic document	Depicts an electronic document (through the IS) that is needed in an activity
	Document	Depicts a document that needed in an activity
	E-mail	Presents the e-mails that should be sent as part of an activity
	Mobile phone	Represents the mobile devices used in activities
Event-driven Process Chain Diagram	Function	Shows the steps and activities that should be followed by companies in order to implement DMAIC
	Event	Add milestones in the beginning and during DMAIC implementation
		The first symbol is an AND rule and the second an OR Rule
	Function (target)	Represents LSS initiatives

Diagram	Object	Object Description
Knowledge Structure Diagram		Depicts the proposed LSS tools and symbolizes the knowledge needed for their implementation
Organizational Chart		Depicts a Department of the company
		Depicts employees positions in the company

Appendix A1.2. Organizational Chart



Appendix A2. Loading times of loading order per shift in Mandra 1

Loading Time of Loading Orders in Mandra 1	Shift	Loading Time of Loading Orders in Mandra 1	Shift
8	7 June A	4	9 June B
1	7 June A	5	9 June B
4	7 June A	13	9 June B
5	7 June A	4	9 June B
10	7 June A	23	9 June B
8	7 June A	13	9 June B
3	7 June A	4	9 June B
4	7 June A	4	9 June B
1	7 June A	40	9 June B
6	7 June A	4	9 June C
8	7 June A	28	9 June C
10	7 June A	4	9 June C
8	7 June A	4	9 June C
6	7 June A	4	9 June C
14	7 June A	4	9 June C
14	7 June B	14	9 June C
8	7 June B	2	9 June C
12	7 June B	3	9 June C
12	7 June B	2	9 June C
6	7 June B	2	9 June C
16	7 June B	10	9 June C
8	7 June B	8	9 June C
2	7 June B	13	9 June C
14	7 June B	12	9 June C
3	7 June B	10	9 June C
8	7 June B	2	9 June C
18	7 June B	2	10 June A
3	7 June B	3	10 June A
9	7 June B	12	10 June A
11	7 June B	12	10 June A
12	7 June B	4	10 June A
12	7 June B	3	10 June A
14	7 June C	5	10 June A
14	7 June C	5	10 June A
8	7 June C	7	10 June A
9	7 June C	3	10 June A
13	7 June C	12	10 June A
8	7 June C	3	10 June A
16	7 June C	5	10 June A
10	7 June C	5	10 June A
19	7 June C	4	10 June A
10	7 June C	4	10 June A
8	7 June C	4	10 June A
8	7 June C	2	10 June B

Loading Time of Loading Orders in Mandra 1	Shift	Loading Time of Loading Orders in Mandra 1	Shift
14	7 June C	16	10 June B
14	7 June C	9	10 June B
8	7 June C	4	10 June B
11	7 June C	18	10 June B
8	7 June C	17	10 June B
9	7 June C	5	10 June B
11	7 June C	11	10 June B
7	7 June C	3	10 June B
16	7 June C	2	10 June B
11	7 June C	10	10 June B
9	7 June C	14	10 June B
24	7 June C	2	10 June B
23	7 June C	17	10 June C
28	7 June C	16	10 June C
30	8 June A	10	10 June C
1	8 June A	9	10 June C
6	8 June A	10	10 June C
4	8 June A	15	10 June C
6	8 June A	12	10 June C
3	8 June A	12	10 June C
6	8 June A	9	10 June C
4	8 June A	11	10 June C
4	8 June A	14	10 June C
5	8 June A	6	10 June C
9	8 June A	20	10 June C
11	8 June A	4	10 June C
11	8 June A	10	10 June C
9	8 June A	46	10 June C
9	8 June B	8	10 June C
6	8 June B	12	10 June C
5	8 June B	13	10 June C
8	8 June B	3	10 June C
11	8 June B	11	10 June C
8	8 June B	5	10 June C
10	8 June B	12	10 June C
5	8 June B	4	10 June C
14	8 June B	14	10 June C
7	8 June B	26	11 June A
9	8 June B	6	11 June A
1	8 June B	6	11 June A
6	8 June B	6	11 June A
8	8 June B	1	11 June A
16	8 June B	5	11 June A
8	8 June B	5	11 June A
8	8 June C	5	11 June A
9	8 June C	1	11 June A
2	8 June C	9	11 June A
19	8 June C	3	11 June A

Loading Time of Loading Orders in Mandra 1	Shift	Loading Time of Loading Orders in Mandra 1	Shift
4	8 June C	3	11 June A
10	8 June C	14	11 June A
10	8 June C	10	11 June A
4	8 June C	10	11 June A
10	8 June C	7	11 June A
3	8 June C	16	11 June A
10	8 June C	11	11 June A
10	8 June C	3	11 June B
3	8 June C	5	11 June B
1	8 June C	5	11 June B
2	8 June C	15	11 June B
10	8 June C	3	11 June B
8	8 June C	3	11 June B
13	8 June C	16	11 June B
20	8 June C	8	11 June B
2	8 June C	10	11 June B
20	8 June C	14	11 June B
4	9 June A	6	11 June B
13	9 June A	10	11 June B
4	9 June A	2	11 June B
13	9 June A	2	11 June B
13	9 June A	1	11 June B
13	9 June A	5	11 June B
2	9 June A	10	11 June C
1	9 June A	12	11 June C
4	9 June A	9	11 June C
4	9 June A	12	11 June C
4	9 June A	10	11 June C
4	9 June A	6	11 June C
4	9 June A	16	11 June C
4	9 June A	2	11 June C
4	9 June A	1	11 June C
9	9 June A	8	11 June C
9	9 June B	14	11 June C
9	9 June B	5	11 June C
1	9 June B	5	11 June C
1	9 June B	3	11 June C
5	9 June B	3	11 June C
5	9 June B	4	11 June C
5	9 June B	7	11 June C
4	9 June B		