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Mestrado em Gestão de Informação
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Supply Chain Business Intelligence -

Model proposal and implementation to support the online sales supply chain end to end operation of a Portuguese electronics retail company

Marcela Alves Freire

Project Work presented as partial requirement for obtaining the Master’s degree in Information Management

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SUPPLY CHAIN BUSINESS INTELLIGENCE - MODEL PROPOSAL AND IMPLEMENTATION TO SUPPORT THE ONLINE SALES SUPPLY CHAIN END TO END OPERATION OF A PORTUGUESE ELECTRONICS RETAIL COMPANY

by

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Project Work presented as partial requirement for obtaining the Master's degree in Information Management, with a specialization in Knowledge Management and Business Intelligence

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ABSTRACT

In today's highly competitive business environment, the adoption of Supply Chain Management is seen as an advantage. It provides not only effective integration, but also cooperation within the supply chain.

However, in order to achieve further integration, other practices are needed. With growing volumes of data, businesses are required to ensure its appropriate flow, integration and analysis.

This project, named "Supply Chain Business Intelligence - Model proposal and implementation to support the online sales supply chain end to end operation of a Portuguese electronics retail company" had as its main goal the development of a conceptual model of a Business Intelligence system to address the needs of an online sales supply chain end to end operation. The proposed model should not focus on a specific company. Instead, it should provide a solution for other similar problems.

The project starts with the definition of the problem, objectives and methodology. It is then followed by the literature review, which consists of a thorough research to identify best practices and previous works in the literature that dealt with similar problems. The research focuses on three main topics: Supply Chain Management, Internet Retail Industry and Business Intelligence.

A conceptual model is then developed, which consists of four main steps: definition of the overall requirements, metrics, data mart model and dashboards. For the data mart model, it is important to identify the business process, the appropriate granularity and respective dimensions and fact tables.

It is then followed by a case study, which consists in the implementation of the model to solve Company X's problem. As outputs of the project, both data mart and dashboards are considered, since they are part of the artifact needed to achieve the business requirements.

Finally, a discussion and evaluation of the results is conducted. Even though the implementation part of the project presented some challenges, the final solution still showed improvements for Company X and proved to be appropriate for the provided business requirements.

Limitations and possible aspects of improvements are presented in the last chapter of the project.

KEYWORDS

Supply Chain; Internet Retail; Online Sales; Business Intelligence; Data Mart; Dashboard.

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LIST OF ABBREVIATIONS AND ACRONYMS

ABI	Analytics and Business Intelligence
B2C	Business-to-Consumer
BI	Business Intelligence
CE	Consumer Electronics
DC	Distribution Centers
DD	Degenerate Dimension
DM	Data Mining
DS	Design Science
DSR	Design Science Research
DSRM	Design Science Research Methodology
DSS	Decision Support System
DW	Data Warehouse
ETL	Extract, Transform and Load
GQM	Goal Question Measurement
GSCF	Global Supply Chain Forum
IS	Information Systems
KPI	Key Performance Indicator
OLAP	Online Analytical Processing
OMS	Online Management System
RMOS	Retail Merchandise Operation System
SA	Sales Assistant
SC	Supply Chain
SCD	Slowly Changing Dimension
SCI	Supply Chain Intelligence

SCM	Supply Chain Management
SCOR	Supply Chain Operations Reference
SKU	Stock Keeping Unit
SSIS	SQL Server Integration Services
SSMS	SQL Server Management Studio
UML	Unified Modeling Language
WMS	Warehouse Management System
YTD	Year to date

1. INTRODUCTION

Given the flexibility and the comfort that online shopping brings to the shopping experience, ecommerce has shown a considerable growth in the past years. As new technologies and trends emerge, it is of great importance that the e-commerce businesses adapt to the new reality.

Some of the biggest challenges faced by these businesses are centered in their supply chain. The purpose of the following project is to present a Business Intelligence (BI) solution to address the needs of the online sales end to end operation from a supply chain perspective. After proposing a conceptual model, its implementation will be conducted concerning a Portuguese electronics retail company. Due to confidentiality terms, the company will not be identified, as well as the specific names for data sources, tables and respective fields. So, in order to deliver the outputs proposed in this project, generic names will be presented and the company will be referred to as Company X.

1.1. BACKGROUND

Every day, businesses face more and more pressure to reduce costs, reduce process times and increase profit. There is an increasing expectation for high quality products and services that need to be delivered at the right time and place. In this business environment, one of the key success factors for companies concerns the implementation of an effective integration strategy between all supply chain collaborators (Stefanovic & Stefanovic, 2009).

In order to provide competitive advantage and to respond to an ever-changing global environment, Supply Chain Management (SCM) was introduced as a new management philosophy (Stefanovic & Stefanovic, 2009). This has been a concept of great value ever since the early 20th century with the development of the first assembly line. However, as a term, it was only introduced to the public in 1982 in an interview given to the Financial Times by Keith Oliver, a consultant at Booz Allen Hamilton. Still, it only became popular with the publication of “Introduction of Supply Chain Management” in 1999 by Robert B. Handfield and Ernest L. Nichols, Jr. The book was translated to Japanese, Korean, Chinese, and Russian and over 25,000 copies were published (Ghosh, 2016).

Instead of viewing Supply Chain (SC) as a set of individual parts, each having its own function and purpose, SCM considers it to be a single entity. After developing a study to find a consensus definition for SCM, Stock and Boyer (2009) came up with the following result: “The management of a network of relationships within a firm and between interdependent organizations and business units consisting of material suppliers, purchasing, production facilities, logistics, marketing, and related systems that facilitate the forward and reverse flow of materials, services, finances and information from the original producer to final customer with the benefits of adding value, maximizing profitability through efficiencies, and achieving customer satisfaction”.

Even with all the benefits that come from implementing SCM systems, they do not have the capability of developing the sophisticated analysis necessary to provide an integrated view of the SC. That is where BI takes place. With its tools and methodologies, such as data warehousing, “Extract, Transform and Load” (ETL), Online Analytical Processing (OLAP) and Data Mining (DM), BI provides the means for the identification, treatment and analysis of business data (Stefanovic & Stefanovic, 2009).

With focus on the past two decades, BI and related fields have grown considerably (Chen, Chiang & Storey, 2012). According to the Gartner Group (n. d.), analytics and business intelligence (ABI) may be defined as “an umbrella term that includes the applications, infrastructure and tools, and best practices that enable access to and analysis of information to improve and optimize decisions and performance”.

Alongside analytics, BI proposes a set of techniques and methodologies which allow for critical business data to be integrated and analyzed, providing businesses the possibility of making better decisions. Through the combination of data mart modelling and tools, it is possible to extract, transform and load the core data into final structured data repositories. Then, with OLAP and reporting tools, explore the data and present it in an intuitive way according to the business needs (Chen, Chiang & Storey, 2012).

1.2. PROBLEM DEFINITION

Company X is a Portuguese retail company that operates in the fields of consumer electronics (CE), household appliances and entertainment. It is currently present in Portugal, including Madeira e Açores, in more than 180 stores. Besides physical stores, it also has an e-commerce channel, through which customers have access to a wide selection of products and brands, including exclusive brands.

For their online sales, the overall process that a purchase order undergoes can be described by five milestones: Payment, System Integration, Expedition, Pickup of Product in the preparation site and Delivery to the final location. These steps are presented in Figure 1.1 below.

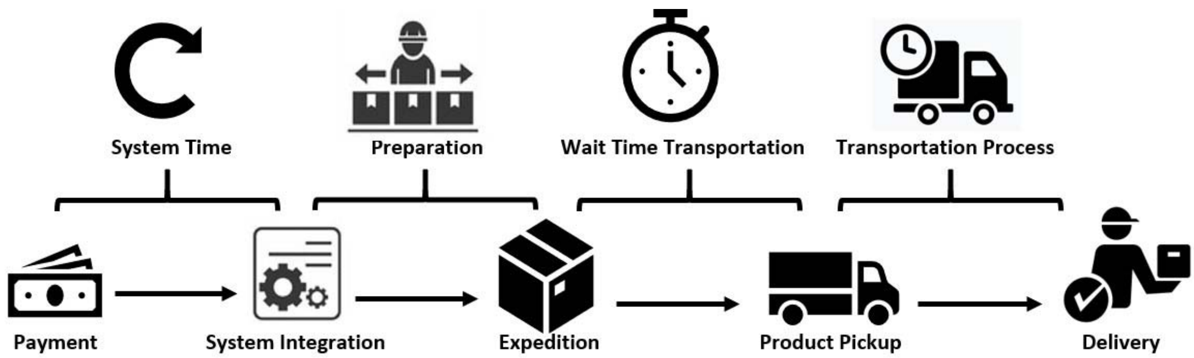


Figure 1.1 – Overall Online Sales Process

Depending on the size of the product, the delivery destination and the preparation site, orders may be subject to different processes. For example, in an omnichannel perspective, online sales may be delivered either in the customer’s home or in a desired pick up store location. Concerning the preparation, orders may be prepared either in the stores or in the warehouse. A store can be both a preparation and a pickup location, whereas the warehouse can only be a preparation location. The possible processes involved in an online sale will later be described in the “Conceptual Model Proposal” section.

Since the customers' satisfaction is one of Company X's main priorities, keeping track of every order and making sure that the delivery is made within the promised date is one of their biggest concerns. In the present moment, the solution developed to address this matter is built using Microsoft Access and Excel, which limits its performance considerably.

As it is not a properly structured solution, updates, errors corrections and other repetitive tasks represent a heavy workload for the members of the supply chain BI team. Also, due to the long time the updates require, it is not possible to deliver analysis in a timely manner, which is a big concern specially during discount events that overburden the supply chain.

In addition, because of changes in the company's supply chain management strategy, the currently used warehouse management system is being replaced. This implicates in the change of processes, data fields mapping and, consequently, in the invalidation of some parts of the current solution.

1.3. Main Goal and Specific Objectives

The goal of this project is to develop a conceptual model of a BI system to address the needs of an online sales supply chain end to end (E2E) operation, which comprehends the entire process since the purchase is made until the product is delivered to the final customer. It must allow the appropriate users to track the progress of each order as well as to assess the overall performance of each of the individual supply chain operations inside the E2E process. The proposed system should include a data mart model and dashboard models that may be applied outside of Company X's reality.

A case study will then be conducted in order to solve Company X's problem by applying the proposed model.

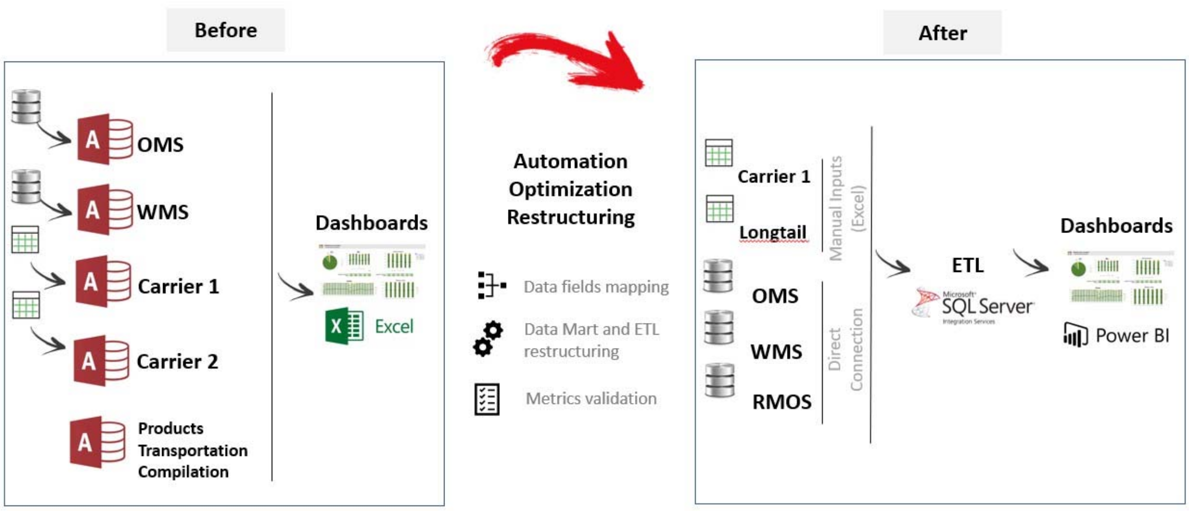


Figure 1.2 – Diagram showing the existing solution and the intended solution for Company X

In order to achieve the goal presented above, the following specific objectives were defined. They were divided into two phases:

1. **Conceptual model development**

   ✦ Identification of the business needs and the appropriate metrics to describe the online sales supply chain operation;

   ✦ Development of a conceptual data mart model, with the identification of the appropriate dimensions, fact tables and granularity that should answer to the previously listed business needs;

   ✦ Proposal of dashboard models that should work as a control panel to monitor the online sales supply chain operation;

2. **Application of the conceptual model to Company X's scenario**

   ✦ Definition of the software to be used;

   ✦ Application of the data mart model in Company X's scenario;

   ✦ Identification of all data sources and development of the fields mapping in order to indicate from which fields, tables, data sources the necessary data can be extracted; ✦ Structuring of ETL processes to make them more efficient for the existing conditions;

   ✦ Application of the previously defined dashboard models in Company X's scenario.

3. **Discussion and evaluation of the results**

   ✦ Analysis in order to understand if the BI solution developed achieved the proposed objectives and business requirements.

1.4. STUDY RELEVANCE AND IMPORTANCE

Below are listed this project's main motivations:

✦ At the moment, Company X's supply chain's BI team is overloaded with time consuming repetitive tasks, which results in a lack of time to develop improvement projects and analytical tasks;

✦ Since a lot of the work is done manually and involves data from multiple data sources, it often presents errors which implicate in the lack of information reliability;

✦ Due to the long time the updates require, it is not possible to deliver the necessary analysis in a timely manner, which is a big concern specially during discount events that overburden their supply chain.

✦ Since there is not a central data repository, there is no consistency when comparing the information provided by different teams in the supply chain;

- ✦ Due to the replacement of the warehouse's management system, some parts of the existing BI solution are no longer valid.

Through the implementation of a well-structured BI solution, Company X will be able to guarantee the quality of what is shared along their supply chain. It will also allow more accurate and faster reporting, it will optimize team members' time and, consequently, improve employee satisfaction. Team members will be able to dedicate their time to more challenging and fulfilling projects, instead of manual repetitive tasks. Finally, it will give Company X competitive advantage in the market by increasing its adaptability. And also allow it to overcome the impact of a change in the warehouse management system.

Besides being relevant to Company X, the conceptual model proposed in this project may benefit other companies that are facing similar challenges. Although each case is different and brings its own needs, the model intends to propose the core fact tables and dimensions for a data mart that allows the tracking of the progress of an online sale throughout the supply chain of a company. Besides that, it should allow for the assessment of the overall performance of each of the supply chain operations involved in an online sale. As well as the data mart model, the dashboard models could be adapted for other company's needs.

In an academic perspective, this project will also be relevant to studies which correlate BI, supply chain and e-commerce. Although it is possible to find many studies concerning BI in supply chain or e-commerce's supply chain, it is not common in the literature to find publications that correlate the three.

1.5. Methodology

In order to develop this project, the chosen methodology is Design Science Research (DSR). According to Peffers, Tuunanen, Rothenberger & Chatterjee (2007), responsible for proposing a framework for Design Science Research Methodology (DSRM), it "contributes to information systems (IS) research by providing a commonly accepted framework for successfully carrying out design science (DS) research and a mental model for its presentation".

DSR has its primary focus set in the creation of new knowledge through the development and design of innovative artifacts and their performance assessment through reflection and abstraction. The outputs of DSR include algorithms, system design methodologies, languages, among others (Vaishnavi & Kuechler, 2004).

As it was already mentioned in the previous sections, the main goal of this project is to develop a conceptual model of a BI system that answers to the needs of an online sales supply chain end to end operation. Since it involves the creation of innovative artifacts and products in the field of IS which intend to answer to a specific problem in its own application environment, the DSRM was considered appropriate for the development of the project.

The DSRM proposed by Peffers, Tuunanen, Rothenberger & Chatterjee (2007) resulted from a consensus building approach which identified the key elements used in prior literature in DS research. The result consisted of a process model composed by six core activities: 1) Problem identification and motivation, 2) Definition of the objectives for a solution, 3) Design and development, 4)

Demonstration, 5) Evaluation, 6) Communication (Peffers, Tuunanen, Rothenberger & Chatterjee, 2007). A graphical representation of the model can be seen in Figure 1.3 below:

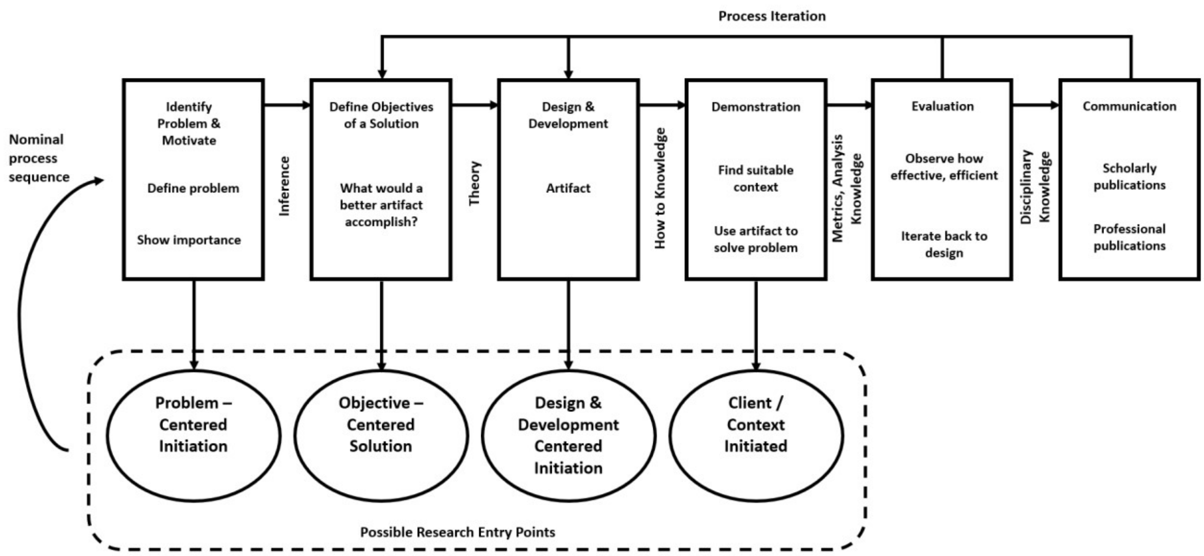


Figure 1.3 – Process Model for DSR. Adapted from Peffers, Tuunanen, Rothenberger & Chatterjee (2007)

Problem identification and motivation: Definition of the specific research problem and the identification of the solution relevance and importance (Peffers, Tuunanen, Rothenberger & Chatterjee, 2007). For this project, the motivation came from Company X's need of a new and improved BI solution focused in its online sales supply chain end to end operation. As it was previously mentioned, the existing BI solution lacked in performance and resulted in time consuming repetitive tasks that overburden the supply chain BI team and resulted in unreliable information. Problem identification and solution value are presented in more detail in the "Problem Definition" and "Study Relevance and Importance" sections.

Definition of the objectives for a solution: Identification of the objectives of a solution which should be inferred from the problem specification. These objectives should be rationally defined (possible and feasible objectives) and can either be quantitative or qualitative (Peffers, Tuunanen, Rothenberger & Chatterjee, 2007). For the current project, as it was specified in the section "Main Goal and Specific Objectives", the main objective is centered in the development a conceptual model and application of a BI system that answers to the needs of an online sales supply chain end to end operation.

Design and development: Creation of the artifact. Artifacts may be constructs, models, methods or instantiations (Peffers, Tuunanen, Rothenberger & Chatterjee, 2007). For this project, the artifact will consist of a conceptual model of a BI system which will be composed of appropriate metrics, data mart model and dashboard models to meet the previously described objective. Even though it is focused in Company X's needs, the artifact must provide a solution that can be adapted for similar applications outside of the company. The design of the model will be defined considering the best practices identified in the "Literature Review" section.

Demonstration: Implementation/demonstration of the previously developed solution in order to solve the identified problem. It may be done by experimentation, simulation, case study, proof or other appropriate activity (Peffers, Tuunanen, Rothenberger & Chatterjee, 2007). For this project, a case study will be conducted through the application of the proposed artifact to Company X's problem. An analysis will be first developed in order to identify the best tools for the implementation of the solution, according to company's available resources.

Evaluation: For this activity, it is necessary to observe and assess how the proposed artifact contributes to the solution of the problem. It consists of comparing the obtained results of the implementation to the previously defined objectives. The evaluation may be done in many forms, such as, quantitative performance measures, satisfaction surveys, client feedback or simulations (Peffers, Tuunanen, Rothenberger & Chatterjee, 2007). For this project, the evaluation will be done through the assessment of the level of achievement of the artifact.

Communication: This activity is based in communication with the purpose of promoting awareness of the problem and its importance, the solution through a proposed artifact, its design and effectiveness (Peffers, Tuunanen, Rothenberger & Chatterjee, 2007). In the current project, communication will be achieved through the development of the present report. Its structure is defined according to the DSRM and its process model.

2. LITERATURE REVIEW

This chapter consists of the literature review that serves as the theoretical basis for the development of the project.

First, a study of SCM and its role in organizations is presented. The specifications of e-commerce supply chain will be described in this section. Following, a topic for the application of BI solutions in the SCM area will be presented.

Finally, the BI topic will be addressed. A study of the best practices in data warehousing, ETL, dashboard design and information visualization will be conducted.

2.1. SUPPLY CHAIN MANAGEMENT

As it was previously mentioned, the term SCM was introduced in the early 1980s by consultants. Since then, it has been used in reference to the planning, control of materials, logistics activities and information flows that exist within and between companies (Chen & Paulraj, 2004). Figure 2.1 below presents a typical supply chain.

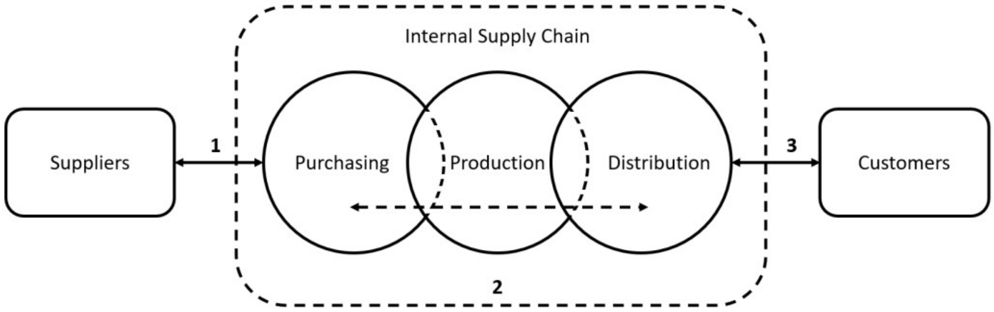


Figure 2.1 – Typical supply chain of a company. Adapted from Chen & Paulraj (2004)

According to Lambert (2014), director of the Global Supply Chain Forum (GSCF), SCM can be defined as "the management of relationships in the network of organizations, from end customers through original suppliers, using key cross-functional business processes to create value for customers and other stakeholders".

Another definition, given by the Council of Supply Chain Management Professionals (CSCMP), states that the area of SCM "encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies" (CSCMP, n.d.).

The proposed framework by Lambert & Cooper (2000) for SCM is composed by three main elements: the supply chain network structure, the supply chain business processes, and the supply chain management components.

When it comes to supply chain network structure, the authors intend to identify which are the key supply chain members with whom to link processes. These members may be defined as being the companies or organizations with whom the main company interacts with, directly or indirectly. If all types of members are included, the total network may become highly complex and difficult to manage. So, in order to make it more manageable, the authors distinguish members as being either primary or supporting. Although this distinction may not be obvious in all cases, it allows for the point of origin and the point of consumption of the supply chain to be defined (Lambert & Cooper, 2000).

Supply chain business processes, on the other hand, refer to all processes that should be linked with the previously defined members. In order to manage an integrated supply chain, it is necessary to have continuous information flows, in which the customer is always the main focus of the process. This only becomes possible with accurate and timely information processing. This allows businesses to respond quickly to any changes in customer demand. Some of the key supply chain processes are: customer relationship management, customer service management, demand management, order fulfillment, manufacturing flow management, product development and commercialization and returns (Lambert & Cooper, 2000).

Last, but not least, Supply Chain Management components refer to the level of integration and management that should be applied for each process link. The level of integration and management may be defined as a function of the components added to the link, in which a higher number and/or level of each component increase the level of integration and management. The authors identify nine main management components that are key for successful SCM: culture and attitude, power and leadership structure, management methods, product flow facility structure, organizational structure, work structure, planning and control and information flow facility structure (Lambert & Cooper, 2000).

2.2. Internet Retail Industry Supply Chain

Defined as being the segment of companies which sell products to customers, the retail industry is characterized by one main relationship: retailer and customer. This relationship leads to the interaction between retailers and suppliers: one retailer may have multiple suppliers, while one supplier may serve multiple retailers. This supply chain is subject to constant change and a dynamic environment in which the main driver is the retail customer. Before, customer purchasing habits could be satisfied only by managing inventory levels. However, their demands have changed and a certain level of customer service is now expected, which leads to the need of innovative solutions (Chiles & Dau, 2005).

For a company's supply chain to be successful, its chosen practices should be aligned with its business strategy. Even though focusing on operational effectiveness and cost reduction may help set a company's position in the market, it is not enough to differentiate it in such a competitive environment. Focusing on performing the same activities better is not enough. According to Hammer (2004), the focus should be in achieving operational innovation, which involves performing different activities or adopting differentiating methodologies. By aligning operational effectiveness and a thought-out business strategy, a company may develop unique practices that may provide continuous performance differentiation (Hammer, 2004).

An important segment of the retail industry is internet retailing. It can be defined as the group of companies that sells products or services though websites that act as online stores. These companies may operate through multiple channels. Traditional companies that only operate through physical stores are referred to as "brick-and-mortar", while multichannel companies with online and physical stores are said to use a "click-and-mortar" strategy. Those retailers which do not operate through physical branches and rely solely on the internet are referred to as "pure-play" (DeYoung, 2001).

As stated by Meyer (2020), the global e-commerce market has reached the mark of $3.5 trillion of sales by the end of 2019, which represents a total share of global retail sales of 14%. Predictions show a growth of two percentage points by the end of 2020 and a total of sales of $4.2 trillion (Meyer, 2020).

With the Covid-19 pandemic and consequent lockdown restrictions and business closures, ecommerce has been a convenient option for consumers to acquire all kinds of goods. In 2020's first semester, June presented the biggest increase in global e-commerce sales, with an increase in volume of 31% when compared to the previous year. Although customers are spending online more regularly, statistics show that the overall spending is slowing down (Toplin, 2020).

E-commerce has changed significantly and is still changing the retailing industry. With its fast growth, internet retail has a great impact on supply chain logistics. Nowadays, companies face the need to adapt their supply chains in order to handle the growing volume of shipments that are now delivered directly to their customers. Also, system changes and better processes become necessary so as to answer to a much higher volume of exchanges and returns (Barry, n. d.). Figure 2.2 below simulates a multichannel company's supply chain which includes Warehousing, Distribution, Information Technology and Transportation Services.

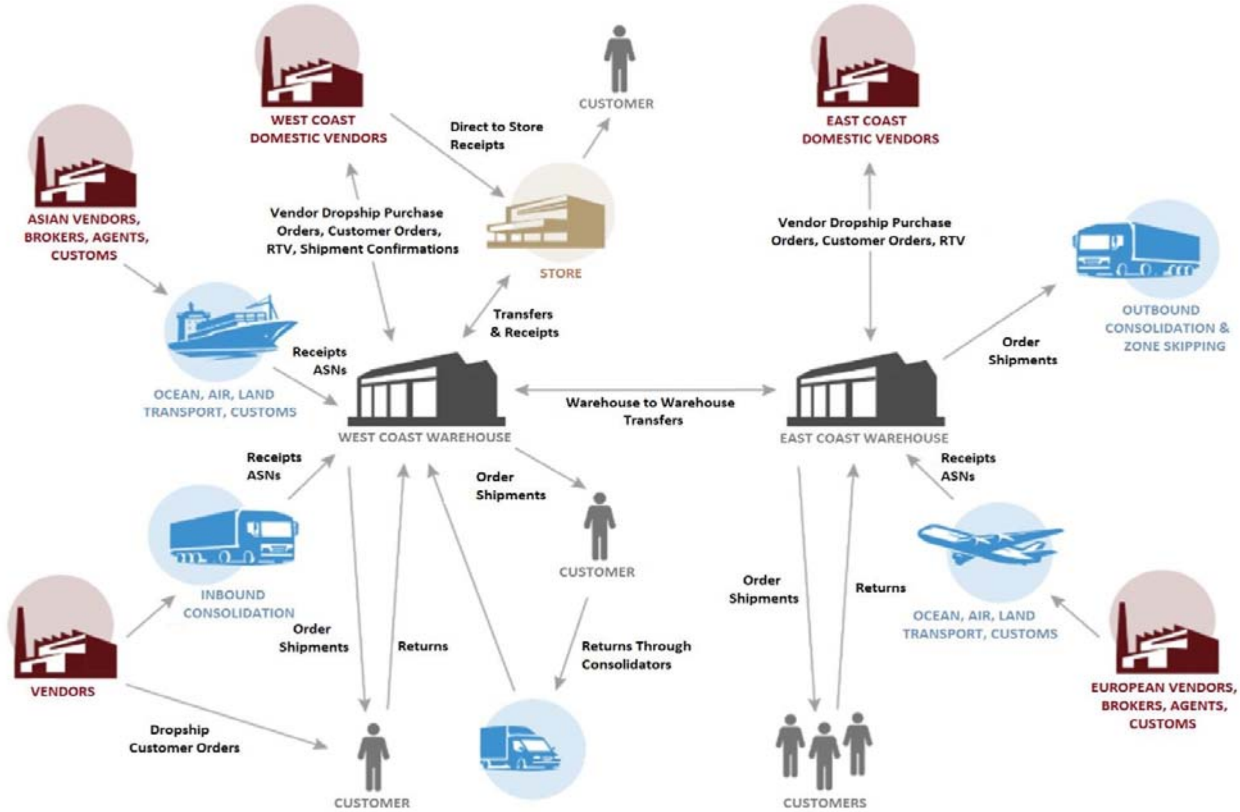


Figure 2.2 – Representation of a multichannel company's supply chain which includes Warehousing, Distribution, Information Technology and Transportation Services. Adapted from Barry (n. d.)

According to Klumpp & Jasper (2008), the changes caused by the e-commerce growth on logistic processes are as follows: change in customers' requirements, multiplicity of heterogeneous products, large number of low volume deliveries and direct delivery.

Change in customers requirements: Due to new buying experiences and to continuous innovation provided by leading e-commerce businsseses, customers' expectations are increasing. Customers expect not only shorter delivery times, but also high availabitity of information in their shopping experiences. For example, in the purchase process, reliable information concerning delivery time as well as the possibility to track the order is expected. Also, with the convenience provided by the internet, customers expect smaller processing times and order fullfilment (Klumpp & Jasper, 2008).

Multiplicity of heterogeneous products: At the beginning, e-commerce opperated specially in the sales of products that could be easily packed or that were digitiseable. With its growth, the assortments available for sale expanded. Products available were then of multiple sizes, formats, contained multiple parts or could even be perishable. This expansion presented new challenges to the supply chain, as it was now necessary to develop new solutions for product storage and transportation (Klumpp & Jasper, 2008).

Large number of low volume deliveries: When it comes to business-to-consumer (B2C) sales, businesses were used to dealing with few, large volume consignments which had to be delivered directly to the physical stores. However, with the expansion of e-commerce, they had to adapt to deal with the ever growing online orders that were mostly small sized and of low volume that had to be delivered directly to the final customer. This presented a challenge as supply chain processes and warehouses layout had to be revised (Klumpp & Jasper, 2008).

Direct Delivery: In traditional retail, when making a purchase, the customer is expected to go directly to a physical store. The stages of picking and delivery are performed by the customer at the place of sale. However, with e-commerce, each purchase is then expected to be delivered at the customer's place of preference, which could mean having to return several times in case of customer's absence. In order not to overload the distribution system, businesses could choose to have these deliveries made by a parcel service, which would mean having additional fixed costs. Another solution would be limiting the supply area. Still, this goes against the goal of e-commerce of expanding the market outside of the area covered by chain stores (Klumpp & Jasper, 2008).

As mentioned before, in order to overcome these challenges and achieve a competitive position in the e-commerce environment, innovation is key. It is no longer acceptable to focus only on performance by developing the same activities as every other business.

When it comes to innovative solutions in e-commerce supply chain, Amazon.com is one of the most referenced businesses. It first began selling books and music online in 1998. Its current scope of products though ranges from video games and electronics to food and cosmetics. According to ScrapeHero (2019), Amazon.com has a range of almost 120 million products as of April 2019. Figure 2.3 below shows Amazon.com's top 10 categories. The measure presented is in millions of products per category.

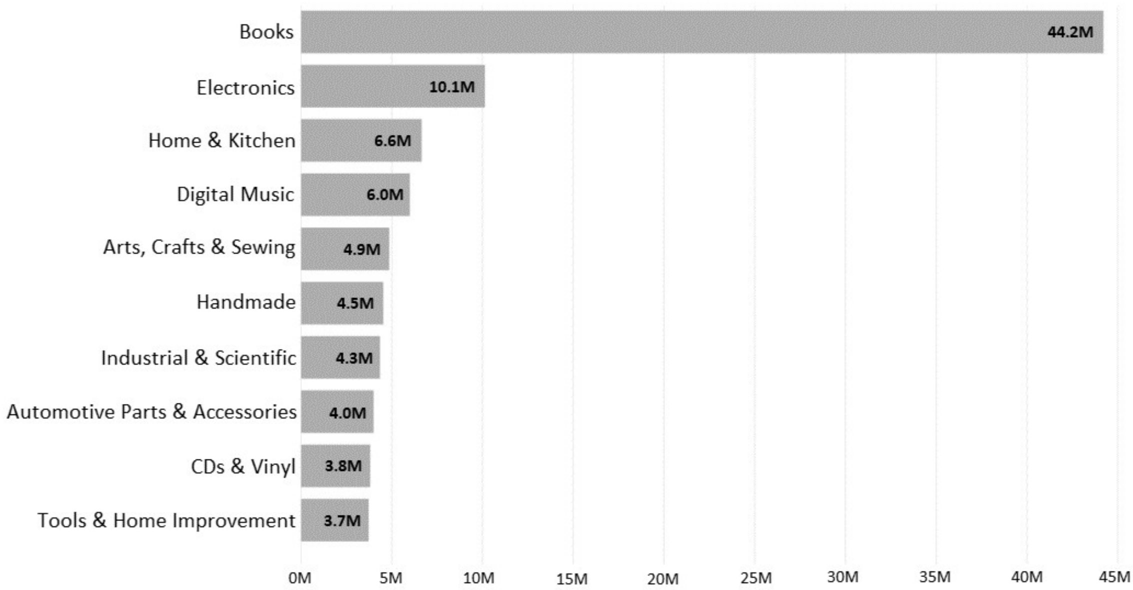


Figure 2.3 – Top 10 categories in Amazon as of April 2019. Adapted from ScrapeHero (2019)

Amazon.com is also present in many different countries, such as United States, Brazil, Spain, the U.K. and many others. In order to grow and overcome the logistic challenges presented, the company relied on technology and innovation. For example, as mentioned by Yu, Wang, Zhong & Huang (2016), the company employed different levels of automation depending on the size and shape of a product. For easily transported products, highly automated processes could be implemented, while irregularly shaped products required a lower level of automation (Yu, Wang, Zhong & Huang, 2016).

When it comes to transportation of orders, Amazon relied on injection points which were strategically placed in districts where there was a high concentration of customers. When a purchase is made, the order first integrates in the distribution centers (DC) where it is prepared and then is shipped to one of these transportation hubs (Yu, Wang, Zhong & Huang, 2016).

Another challenge faced by businesses concerns storage and inventory levels. Instead of keeping high inventory levels, Amazon integrated the inventories in their DCs with the inventories available in their partners' warehouses (Chiles & Dau, 2005). This means that the accessibility to its partners' inventories allowed the company to keep lower inventory levels. Instead of keeping the products in its own DCs, it may ship an order directly from the partner's warehouse. The location for these DCs was defined taking into consideration both the level of taxes and the distance from the districts with high concentration of customers (Yu, Wang, Zhong & Huang, 2016).

2.3. Business Intelligence in Supply Chain Management

As stated by Liu (2010), in today's highly competitive market, adopting SCM became a form of obtaining advantage. The author states that competition is no longer between enterprises, but between supply chains. Great competitive advantage can then be achieved by guaranteeing effective integration and cooperation within the supply chain. A higher level of integration requires effective information flow and analysis, which can only be obtained through the implementation of the appropriate practices and technologies (Liu, 2010).

Waller & Fawcett (2013) note that every day more and more data is recorded and it presents both opportunities and challenges in SCM. The growing volume of data resulted in data sets so big that it is no longer practical to use conventional data management tools. In Table 2.1 below, the authors present examples of potential applications of big data in logistics.

Users	Forecasting	Inventory management	Transportation management	Human resources
Carrier	Time of delivery, factoring in weather, driver characteristics, time of day and date	Real time capacity availability	Optimal routing, taking into account weather, traffic congestion, and driver characteristics	Reduction in driver turnover, driver assignment, using sentiment data analysis
Manufacturer	Early responde to extremely negative or positive customer sentiment	Reduction in shrink, efficiente consumer response, quick response, and vendor managed invetory	Improved notification of delivery time, and availability; surveillance data for improved yard management	More effective monitoring of productivity; medical sensors for safety of labor in factories
Retailer	Customer sentiment data and use of mobile devices in stores	Improvement in perpetual inventory system accuracy	Linking local traffic congestion and weather to store traffic	Reduction in labor due to reduction in misplaced inventory

Table 2.1 – Examples of potential applications of big data in logistics. Adapted from Waller & Fawcett

(2013)

Considering the potential in big data, analytics and with the proper set of tools and techniques, it is possible to produce breakthrough insights that may lead to risk and cost reduction while providing higher service levels and operational agility (Deloitte & MHI, 2016).

According to Ittmann (2015), one of the greatest trends observed among companies in the past years is the awareness of the necessity for decision-making processes to be more data-driven. The author also presents the events that combined contributed for the expansion of supply chain analytics: growing supply chain data, cheaper data storage, faster and ever-increasing processing power, anywhere and anytime connectivity since mobile data is available almost anywhere, better tools that made analysis simpler and advanced tools and techniques for data visualization.

As stated by Langlois & Chauvel (2017), a great volume of data is produced within the supply chain and it has to be processed. The greater the volume, the greater the competition. The expectations for faster deliveries and decision making are high. In this context, BI provides the means for businesses to achieve success and manage their supply chain more efficiently (Langlois & Chauvel, 2017).

As it was already mentioned in the "Introduction", the Gartner Group (n. d.) defines analytics and business intelligence (ABI) as "an umbrella term that includes the applications, infrastructure and tools, and best practices that enable access to and analysis of information to improve and optimize decisions and performance".

The framework for developing a Business Intelligence system may be represented through the following stages: identification of all the different data sources and mapping of the data according to the business needs, ETL (extraction, transformation and load) of the previously identified data into a data warehouse and data marts, development of reports, cubes, use of data mining methodologies and optimization (Vercellis, 2009).

This framework, however, evolved into what can be seen in Figure 2.4. According to Hansen (2020), data marts came to be due to the fact that the "central data warehouse couldn't scale to meet the different workloads and high concurrency demands of end-users". Data lakes, on the other hand, traditionally used to store raw data, became a necessity once the traditional data warehouse "wasn't able to store and process big data (in terms of volume, variety, and velocity)" (Hansen, 2020).

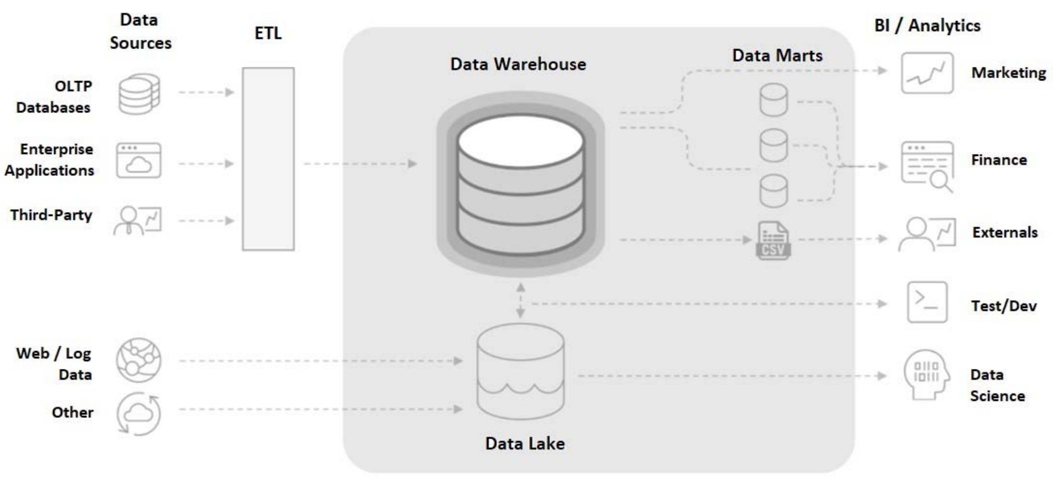


Figure 2.4 – Modern data architecture. Adapted from Hansen (2020)

According to Nenad Stefanovic, Vidosav Majstorovic & Dusan Stefanovic (2006), an appropriate supply chain intelligence (SCI) model would be as follows n Figure 2.5.

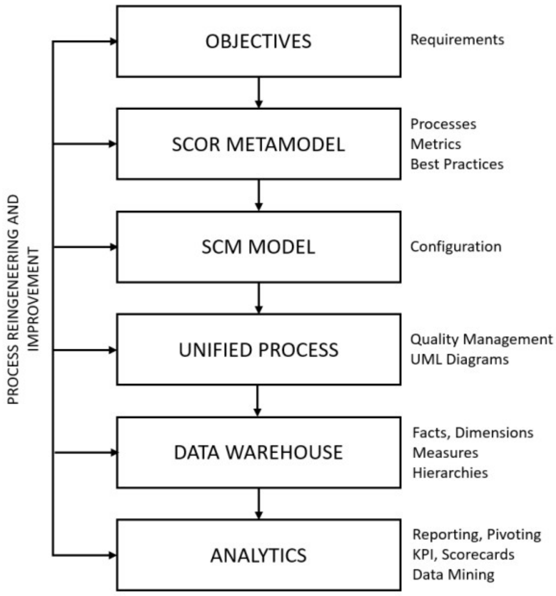


Figure 2.5 – SCI Global Model. Adapted from Stefanovic, Majstorovic & Stefanovic (2006)

After defining the business requirements, the authors base their model in a Supply Chain Operations Reference (SCOR) model which "contains standard descriptions of management processes, a framework of relationships among the standard processes, standard metrics to measure process performance, and management practices that produce best-in-class performance" (Stefanovic, Majstorovic & Stefanovic, 2006).

Further, they focus in a specific business subject which results in the development of diagrams using the Unified Modeling Language (UML). After the definition of specific processes, the SCI model leads to the development of a data warehouse which involves designing schemas with the definition of the appropriate fact tables, dimensions, measures, hierarchies and aggregations. The last step is analytics and it involves the development of reports, key performance indicators (KPIs), data mining analysis and scorecards (Stefanovic, Majstorovic & Stefanovic, 2006).

2.3.1. Data Warehouse

According to Inmon (2002), a data warehouse is a data repository that composes the "heart of the architected environment" and should support management's decisions. The author notes that a data warehouse (DW) should have the following characteristics: subject oriented, integrated, nonvolatile, and time-variant.

Subject Oriented: Instead of providing information concerning a company's ongoing operations, the data warehouse should be modeled according to the specific subjects of interest. For example, sales and marketing can be subject areas.

Integrated: As stated by Inmon (2002), this is the most important aspect of a data warehouse. As the data is extracted from various data sources, transformed and loaded, it should keep its consistency. Formatting and naming conventions should be universally accepted within the company. This means that, once the data is loaded within the data warehouse, there should be a "single physical corporate image".

Nonvolatile: By this, the author means that unlike in the operational environment, data within the data warehouse is not updated or erased. When data undergoes any changes, the record is kept and a new snapshot record is written (Inmon, 2002). This helps further historical data analysis and understanding.

Time-Variant: In the data warehouse, data is always associated with a certain moment in time. Every record is accurate at some point in time. Some even contain a time stamp (Inmon, 2002).

Kimball & Ross (2011) propose a four-step process for designing a data warehouse model. The steps are the following: 1) Select the business processes, 2) Define the granularity (level of detail associated with fact table measurements), 3) Identify the dimensions (provide description for the measurements), 4) Identify the facts.

In order to implement dimensional models in relational database systems, the authors present the use of star schemas. It is considered the simplest form of schema and is widely employed in the development of data marts. The name is due to their star-like structure, as it is shown in Figure 2.6 below.

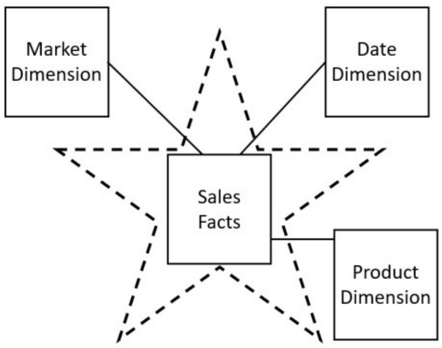


Figure 2.6 – Star Schema. Adapted from Kimball & Ross (2011)

In Figure 2.6 above, it is possible to see that the center of the star is composed by the fact table. This table stores summarized records of business process events and their respective performance measurements (Kimball & Ross, 2011). The dimensions, on the other hand, would be the ends of the star. These tables are used for descriptive purposes and provide context to the business process events in the fact table.

According to Han, Pei & Kamber (2011), another form of a multidimensional model would be the fact constellation schema. It is mostly used in more sophisticated applications in which more than one fact table is needed. Dimension tables are then shared between the multiple fact tables.

Authors Han, Pei & Kamber (2011) also clarify the difference between data warehouse and data mart. While a data warehouse gathers information concerning the entire organization, a data mart is focused on a single department. The authors refer to the data mart as "a department subset of a data warehouse that focuses on selected subjects". They state that, due to its complexity, fact constellation schemas are more commonly used in, but not restricted to, data warehouses. Then, for a data mart, a star schema would be more common (Han, Pei & Kamber, 2011).

2.3.2. Information Visualization and Dashboard Design

As stated by Ware (2013), "we acquire more information through vision than through all of the other senses combined".

Nowadays, the term "visualization" is strongly related to graphical representations of data or concepts and is an important part of the decision-making process within companies.

According to Ware (2013), visualization brings a series of advantages, being these the following:

- The capability of making sense of large volumes of data;
- The ability to identify patterns and obtain insights that otherwise were not evident;
- The improvement in data quality control; visualization provides a better perception when it comes to how the data was collected and if there are any problems with it;
- Visualization also contributes to the formation of hypothesis.

The visualization process consists of four major stages: 1) data collection and storage; 2) preprocessing of data in order to make it easier to work with; 3) transformation of data into visual representation; 4) visual and cognitive processing of information. Figure 2.7 below presents a diagram with the visualization process:

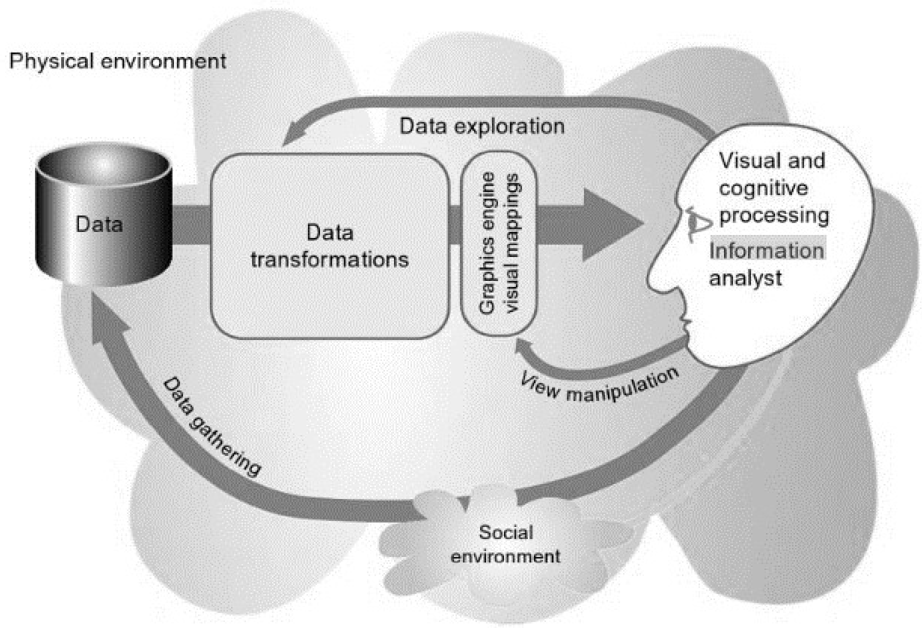


Figure 2.7 – Visualization process. Adapted from Ware (2013)

According to Hubbard (2014), measurements are important because of three main reasons: 1) they support decision making processes; 2) some measurements present their own market value and can be sold to interested parties (an example would be the results of consumer surveys); 3) measurements can have an entertaining purpose, so as to satisfy user curiosity or bring clarification.

When it comes to decision making, reason 1 presented above, Hubbard (2014) states that "management needs a method to analyze options for reducing uncertainty about decisions".

Given the need for proper measurements and data visualization, dashboards became extremely popular. Bakusevych (2018) defines a dashboard as "an at a glance preview of the most crucial information for the user at the moment he is looking at it, and an easy way to navigate directly to various areas of the application that requires users' attention".

In order to design an ideal dashboard, Janes, Sillitti & Succi (2013) propose a technique consisting of two main steps: 1) selecting the proper data to extract and 2) choosing the proper data visualization technique.

1. **Choosing the proper data:** The authors propose a Goal – Question – Measurement (GQM) model. A model diagram is provided in Figure 2.8 below.

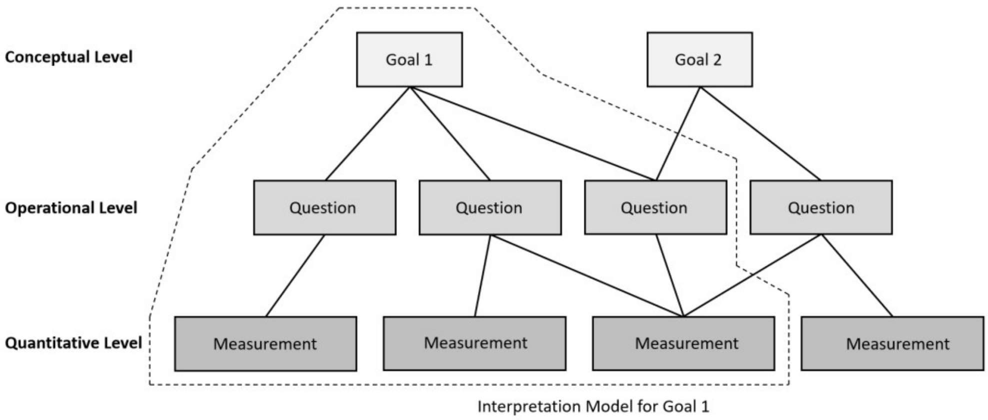


Figure 2.8 – GQM model. Adapted from Janes, Sillitti & Succi (2013)

   a) **Goal:** The "goal" part (conceptual level) is consisted of defining the purpose of the study, which gives a notion of reason, environment, points of view and what aspects to consider to deliver the final result;

   b) **Question:** The "question" part (operational level) considers which aspects, processes and their properties are relevant, taking into consideration the "goal" and what is necessary to achieve it;

   c) **Measure:** The "measure" part (quantitative level) takes into consideration the questions provided in the previous level and define which would be the proper data to collect to answer them.

2. **Choosing proper visualization:** According to the authors, in order for the user to obtain specific information from a dashboard, the following considerations should be taken into account:

a) Visualizing the dashboard should be effortless. For example, it can be displayed in monitors positioned in strategic places inside the company;

b) Interactions with the dashboard should be avoided, meaning the visualization should be enough for the user to understand the data. Interactions should only be used when the user wants to investigate further;

c) Visualizing and understanding the dashboard should be a fast and easy process, which implies that changes in the design should be avoided (always display the same information in the same place);

d) Use techniques to draw the attention of the user to the most important information, but not overdo it;

e) Make the design and the visuals appealing to the users in order to draw their attention to the dashboard and capture their interest.

Bakusevych (2018) also provides guidelines for designing a dashboard. Similarly, from the first presented model, the first step would be defining the purpose of the dashboard. For example, dashboards can be categorized as: analytical, strategic, operational and tactical. In the present project, the purpose is to design operational dashboards which deal with time-sensitive tasks. By providing information in a quick and effective way, the users are able to visualize deviations and take immediate action. Still, when it comes to an overall analysis of the E2E process, analytical, strategic and tactical level information may be present in the design of the dashboard.

The author then proposes choosing the proper visualization for the data (Bakusevych, 2018). In order to achieve effective communication of information within a company, choosing the right chart type is essential. The chosen chart should correspond to the purpose of the displayed information, if it is either a comparison, a distribution, a composition or a relationship (Abela, 2006). Figure 2.9 below presents a guideline for the process of defining the right chart:

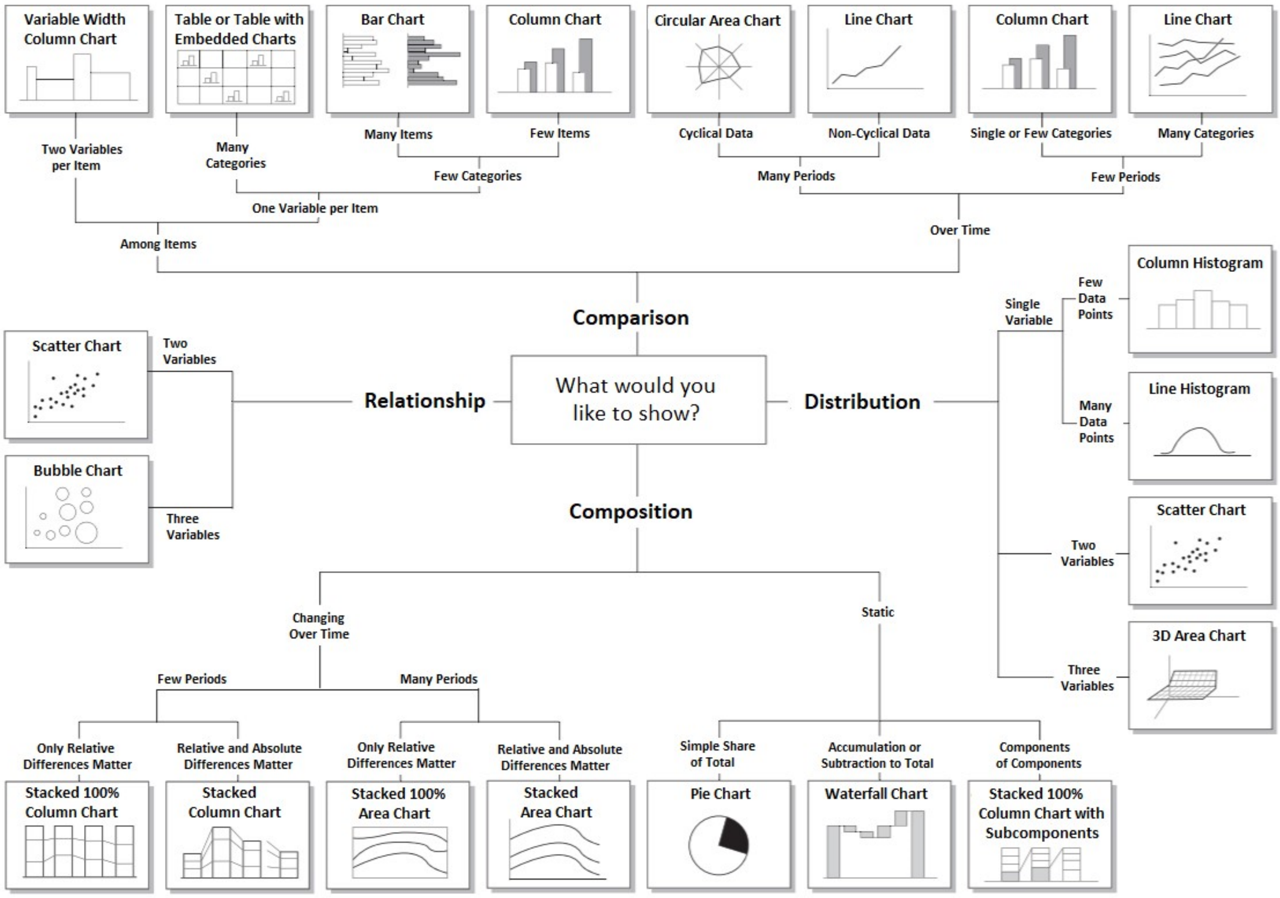


Figure 2.9 – A guideline for choosing the proper chart. Adapted from Abela (2006)

In the next step, the author gives a reminder to stick to naming conventions and to provide effective formatting. Large values should be truncated and dates should be clear. Dashboards are supposed to deliver the right information, at the right time, in a clear and effortless way (Bakusevych, 2018).

Finally, Bakusevych (2018) addresses the dashboard design theme. According to the author, the visualizations should provide the key information. As users tend to “read” dashboards similarly as they do with texts, their attention is primarily drawn to the top left corner. Figure 2.10 bellow presents a diagram of how people usually scan through dashboard content.

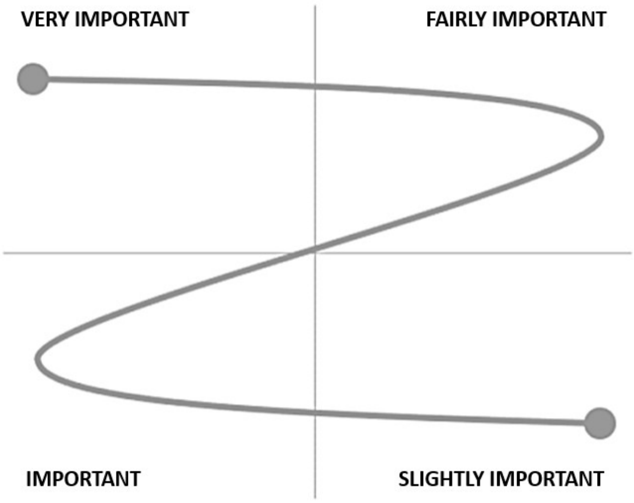


Figure 2.10 – Reading gravity. Adapted from Reporting Impulse (2019)

While important information should have large representations and should appear in areas users are more likely to draw their attention to, less important information should be handled with an opposite approach (Few, 2007). Also, there should be a continuous flow in the dashboard. Related information should be displayed together in order to avoid going back and forth (Bakusevych, 2018).

3. CONCEPTUAL MODEL PROPOSAL

The present chapter consists of the “Design and Development” step proposed in the DSR methodology.

As mentioned in the “Main Goal and Specific Objectives” section, this conceptual model must be designed to not only answer to Company X´s needs, but to present a solution to similar problems outside of the company. Still, one of the main motivations for this project is focused on Company X´s supply chain E2E operation. That being said, comprehending the company´s existing process flows is crucial.

So, initially, this chapter presents a “Context” section consisted of the process flows and the identification of the target users.

Following, in the “Overall Requirements” section, the needs observed for Company X are extrapolated. Only the key requirements are listed so as to make this conceptual model adaptable to other companies with similar needs.

Then, in “Measures and Metrics”, as the title says, the proper measures and metrics are chosen.

In the next three sections, a proposal for the system architecture, data mart conceptual model and dashboards conceptual models is made.

3.1. CONTEXT

As it was previously discussed in the literature review, Nenad Stefanovic, Vidosav Majstorovic & Dusan Stefanovic (2006) proposed a SCI model composed of six main steps. According to the authors, after defining the objectives and requirements, a SCOR model must be made. Since a complete SCOR model for the supply chain is not part of the scope of this project and is not viable, only the main process flows needed to provide a solution will be discussed. Then, in the following sections, proper metrics and KPIs will be defined.

For Company X, the supply chain E2E operation can be divided into three main groups: Systems, Operation and Transportation. Before explaining the responsibilities for each of these groups, an overall view of the online sales process will be given. Figure 3.1 below presents a diagram of the process.

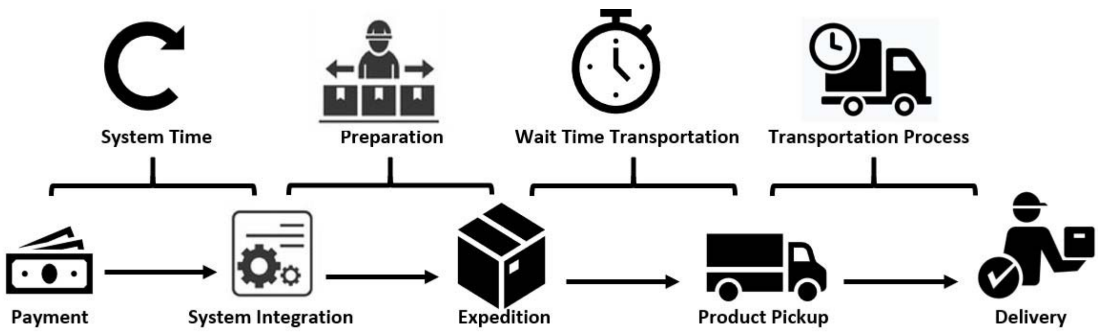


Figure 3.1 – Overall Online Sales Process

As it can be seen, the overall E2E process is composed of five milestones: payment, system integration, expedition, order pickup and delivery. Each of these is identified by a timestamp in their respective system.

From the moment the customer makes the purchase to the moment it integrates in the system, the order is said to be responsibility of the teams within the Systems group. Only after the order integrates it becomes available to be prepared and packed.

The next major group comprehends the period between system integration and expedition. It is when the picking and packing of each Stock Keeping Unit (SKU) within each order is done. The responsibility for these activities is assigned to the Operation group. Due to the confidentiality term and since it is not part of the scope of the project, a further study of the detailed warehouse preparation process will not be conducted.

On the other hand, the responsibility for the wait time between the expedition and the order pickup is not assigned to any of the groups. The impact of this time gap can only be analyzed in the performance evaluation of the overall E2E process.

Last, but not least, the responsibility between the package pickup and the delivery to the customer is assigned to the “Transportation” group.

Each of these groups is composed by multiple teams that give support to specific activities within the mentioned time periods. Nevertheless, the understanding of these activities is not essential for the development of the project.

Different orders may have different specifications and it is important to understand the possible variations between them. The possible variation factors are listed below and are divided into: Sales channel variables, Process flow variables and Product variables.

1. **Sales channel variables**

    a. An online sale may either be done through the website directly by the customer or with the help of a Sales Assistant (SA) in a store. Still, this factor does not result in variations in the overall online sales process.

    b. Through the website, the customer also has the option of making purchases through the Market Place. The preparation and delivery of these products is not done through Company X’s supply chain E2E operation and should not be considered in the implementation of the model.

2. **Process flow variables**

    a. The preparation and packing of each order can either be done in the warehouse or in a supplier store. Supplier stores are regular, physical stores that besides doing direct, on time, sales to customers, also participate in online orders preparation. The purpose is to reduce transportation times and costs since these stores may be closer to the customers’ chosen places of delivery. The present factor results in a variation of the overall process when the preparation is done in a store. The timestamps for the payment and system integration milestones become the same. A diagram for the supplier store online sale E2E process is shown in Figure 3.2 below.

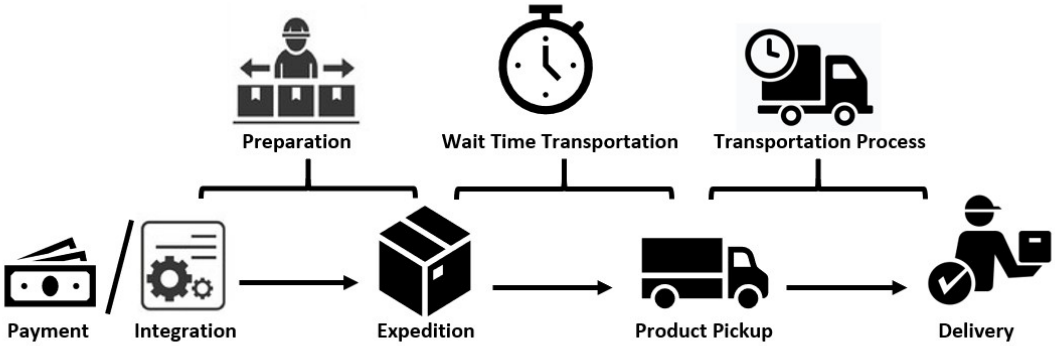


Figure 3.2 – Supplier Stores online sales E2E process

b. Company X works with two different shipping companies. Due to the confidentiality term, they will be referred to as Shipping Company Y and Shipping Company Z. They each have different order pickup times and delivery specifications. While supplier stores only work with Shipping Company Y, the warehouse may work with both. To determine which company will make the delivery, the Warehouse Management System (WMS) analyzes the previously defined times and weekdays when each shipping company does orders pickup. The chosen company will be the one that reduces delivery times and costs. Although this factor does not implicate in processes modifications, it will result in additional data sources to be integrated in the ETL stage.

c. When making an online purchase, the customer is given the option to receive the order in a physical store or in an address of choice. If the place of delivery is coincidentally the supplier store where the order is prepared, there is no transportation time and the timestamp for the expedition becomes the same as the delivery. The change in the process is shown in Figure 3.3 below.

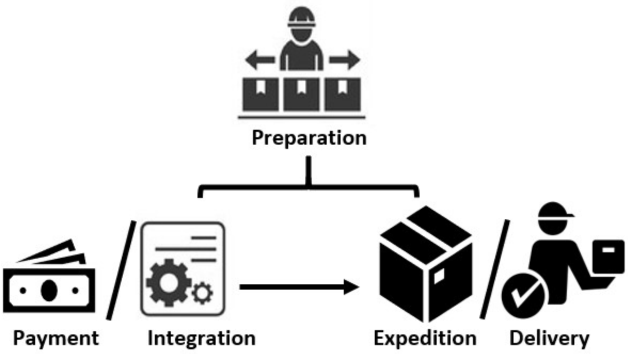


Figure 3.3 – Online sales E2E process for orders that are prepared in a supplier store that coincides with the chosen delivery store

d. In the warehouse, after the products are picked, they are separated according to their dimension. In the small formats' classification, it is possible to have both small and medium volumes. With the intent of reducing costs and optimizing the transportation process, small volumes that need to be delivered at the same physical store are gathered in what is called an aggregation box. This does not change the overall process, but a new aggregation tracking number is assigned to that unit of the purchase order.

e. An online purchase may be classified as mono or multi according to the number of units purchased. Mono implies that only one unit of a single SKU was purchased. Multi, on the other hand, are orders with more than one unit that can have repeated SKUs or not. It is important to mention that, in a multi situation, the units are not necessarily delivered together. Different tracking numbers may be assigned to different units within the same order. For example, when there are multiple items and only one of them is a longtail or even a large format, the order will be split into more than one shipment. However, these cases represent a minority of the online orders. Most of them are mono and only a small percentage of the multi orders get separated into different shipments. The overall process for each unit remains the same, with the exception of large formats. Nevertheless, this shows the need for a system that is able to track each unit individually within an online order.

3. Product variables

a. Some of the products available for sale in the website have very specific characteristics or are not usually present in the stock of any store or warehouse. With the purpose of fulfilling the customers' orders, these items have to be first sent from the supplier to the warehouse. These are called longtails. Every week, a member of the supply chain BI team receives a list with the SKUs to be considered as longtails that week. It is important to properly identify these items once they can have impact on the delivery date and, consequently, on the overall performance of the E2E online sales operation. This, however, is not considered a variation in the process.

b. A similar situation occurs with pre-orders, which cannot be shipped to customers before the supplier's authorized date. If not properly identified, these sales may have a negative impact on performance of the involved teams. It does not impact on the overall process though.

c. The products available for sale can be classified as small or large formats. For example, washing machines and fridges are considered large formats, while mobile phones, video games and toys are considered small formats. The two will undergo very different processes until the final delivery. The overall process shown in Figure 3.1 only applies to small formats. Large units will not only go through a different process but will also be transported by a different shipping company. Due to these differences, large formats will not be considered in the model and are not in the scope of the project.

After explaining the variation factors above, it is possible to establish the following abbreviations:

1. **Order type:**

a. PIS: Pickup in store;

b. HD: Home delivery (can only be done through Shipping Company Y);

2. **Process flow type:**

    a. SS-PIS: order prepared in a supplier store but delivered in another physical store;

    b. SS-Y-HD: preparation is done in a supplier store, transportation is done through Shipping Company Y and delivery is done at the customer's chosen address;

    c. SS-SS: the supplier store is both the preparation and pickup site;

    d. WH-Y-HD: preparation is done in the warehouse, transportation is done through Shipping Company Y and delivery is done at the customer's chosen address;

    e. WH-Y-PIS: preparation is done in the warehouse, transportation is done through Shipping Company Y and delivery is done at a physical store;

    f. WH-Z-PIS: preparation is done in the warehouse, transportation is done through Shipping Company Z and delivery is done at a physical store.

Finally, it is important to discuss the established delivery time intervals and expectations that allow for the supply chain operation to assess its performance.

For the overall E2E process, Company X has the commitment of delivering the orders in the next business day after being purchased. Considering their cutoff time at 7 PM, every purchase made before that time should be delivered in the next business day. Purchases made after 7 PM are considered to be made on the following day.

Also, each one of the mentioned groups (Systems, Operation and Transportation) have their own time interval goals to achieve. When it comes to Systems, it is expected for the time gap between payment and integration to stay under 20 minutes.

The Operation group, on the other hand, has its cutoff time ate 7 PM. The teams are expected to complete the product preparation on the same day, meaning that every purchase that integrates in the system before 7 PM is expected to have the expedition on the same day. Exceptions exist on weekends and holidays.

For the Transportation group, a commitment date is defined according to the next business day rule. Their performance is then assessed through the comparison of the commitment date with the actual delivery date.

3.2. Overall Requirements

After discussing Company X's online sales supply chain E2E operation, it is possible to define the basic requirements for the development of the conceptual model. Once again, it is important to mention that the purpose of the model is to provide a solution that can be adapted to solve similar problems outside of Company X.

The present project should provide a model that can be adapted to companies that are either “clickand-mortar” or “pure-play”. The specifics within each company’s E2E process are not relevant for the development of the conceptual model and should not be considered in the basic requirements.

To make this model adaptable, it is important to look at the overall process and its five milestones: payment, integration, expedition, order pickup and delivery. No matter how different the companies are from one another, it is highly probable that their online purchase orders undergo these basic milestones. So, it is still possible to think of the process as being consisted of three major groups: Systems, Operation and Transportation.

Systems will deal with how the orders become available for preparation from the moment they are created and payed to the moment the Operation obtains clearance to start picking and packing. It is crucial that, at this stage, all the relevant information about the customers preferences is correctly attached to the order object that will be passed on to the Operation. There are obvious items, such as SKUs, and delivery address. But there are also examples of more sophisticated options, such as wrapping, engraving or messages in cards. All of these must be available as soon as the preparation request arrives at the Operation, so that the process can be optimized.

Operation, on the other hand, deals with the preparation process. There are major differences between companies when it comes to their preparation strategy. Amazon, for example, operates with a highly automated warehouse, while others have an operation that combines both human labor and automation. However, these specifics should not have any impact on the model, which focuses on the macro process rather than in each specificity of the process, either conducted by a machine, a person or both.

Finally, “Transportation” deals with the delivery of the purchase order. Its responsibility is to manage the available transportation means so that the customers receive their orders on time and at their place of choice. Nowadays, companies adopt many different transportation solutions, ranging from traditional truck deliveries, to autonomous delivery devices, such as Amazon’s Scout (Amazon, n. d.). Urban areas are more prone to technological advances, whereas rural areas often have less availability and more traditional solutions.

It is important to mention that each company will have its own specificities. Orders may be cancelled, out of stock, delivered to the wrong address or even undergo processing and payment problems. These cannot be defined in the conceptual model stage, but may appear as a status field for their respective process group.

Below, are listed the basic requirements for the development of the conceptual model:

- The conceptual model should provide the possibility to track each purchase order from the moment it was created to the moment of delivery;
- Each milestone should have a corresponding timestamp;
- Considering that purchase orders can have one or multiple units, they may or may not be transported in the same shipment. So, it is important that the data is presented on a unit level, meaning that each record should correspond to a single unit of a purchase order;

- The purpose of the model is to support different teams within the supply chain that are responsible for the fulfillment of online sales. Consequently, metrics and KPIs should be defined according to the target users of each dashboard;

- In order to deal with time-sensitive tasks and to support important campaigns (such as Black Friday), users on an operational level should have access to updated information on an hourly basis. This constitutes Operational BI;

- Users should also be able to visualize the orders on an extended period of time (days to weeks or months) and their distribution between the milestones. It allows teams to be informed of any backlog that needs to be taken care of, conduct short term analysis and reach strategic goals. This constitutes Tactical BI;

- It is of interest of supply chain executives to be able to compare metrics and KPIs over extended periods of time (months to years). It helps them reach long term organizational objectives). This constitutes Strategic BI;

- KPIs need to allow for each group (Systems, Operation and Transportation) to assess their individual performances. This should be done in both tactical and operational level;

- The assessment of the performance of the overall E2E process is also needed. Since the supply chain directors and analysts would be the main target users, strategic and tactic level information should be the focus;

- To support "Systems", "Operation" and "Transportation" teams, most of their indicators should provide operational level information. They should be quick and effective, so that users are able to visualize deviations and take immediate action.

3.3. MEASURES AND METRICS

Since measures and metrics should be aligned with the company's strategy, it is not appropriate to base their definition solely on Company X's experience. Still, when it comes to key metrics to support the online sales E2E process, it may help with possible insights.

That being said, this section will be developed based on the compilation of what is found in the literature and adapted to fit the previously defined requirements. Company X's previous experience may help shape the final result.

In order to achieve the objectives proposed on this project, the defined measures and metrics should focus on **order information**. Also, they should be specific to each group (Systems, Operation and Transportation) and reflect the information needs of their target users.

So, the first step is to establish the theme for each dashboard and the users they need to reach. Further understanding of the dashboards will be given in the final topic of the chapter. Below, Table 3.1 presents the themes for the dashboards, the expected level of information and the respective target users.

Dashboard Theme	Level of Information	Target users
Systems Purchase Orders Information	Operational / Tactical	IT teams responsible for maintaining the core systems that manage online sales
Operation Purchase Orders Information	Operational / Tactical	Warehouse Online Operation Team and Warehouse Operations Manager
Transportation Purchase Orders Information	Operational / Tactical	Teams responsible for B2C transportation
Online Sales Supply Chain E2E Process Summary	Tactical / Strategic	Supply Chain Executives and Warehouse Operations Managers
Online Sales Supply Chain E2E Process Summary (Campaign Season)[1]	Operational / Tactical	Supply Chain Executives and Warehouse Operations Managers

Table 3.1 – Dashboards and their target users

It is important to mention that it may be of interest of the supply chain's continuous improvement team to have access to these metrics. However, each company's supply chain is unique, and this may not be a reality.

Chae (2009) proposes a system in which metrics are divided into two layers, primary and secondary. Primary metrics consider a company's overall supply chain performance. The target users are usually supply chain members of top and middle management. Secondary metrics, on the other hand, provide an understanding of primary metrics deviations and give a deeper and more detailed view of the supply chain (Chae, 2009). Figure 3.4 below shows the proposed supply chain metrics according to these two layers:

[1] Demanding campaigns, such as Black Friday, may require closer monitoring; order fulfillment updates should be at least on an hour basis.

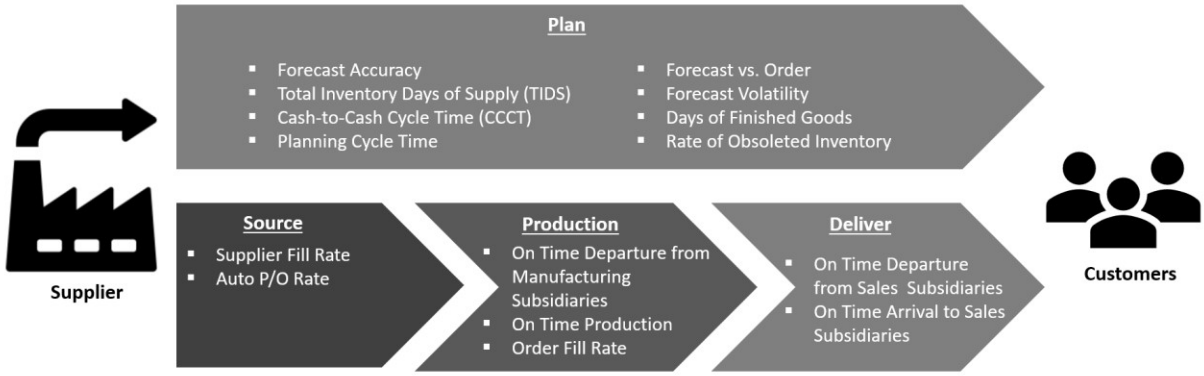


Figure 3.4 – Proposed supply chain metrics. Adapted from Chae (2009)

Gunasekaran, Patel & McGaughey (2004) also propose a framework for measuring supply chain performance. The authors discuss possible measures and metrics for specific supply chain activities. Table 3.2 below presents the proposed framework:

Supply chain activity / process	Strategic	Tactical	Operational
Plan	Level of customer perceived value of product, Variances against budget, Order lead time, Information processing cost, Net profit vs. productivity ratio, Total cycle time, Total cash flow time, Product development cycle time	Customer query time, Product development cycle time, Accuracy of forecasting techniques, Planning process cycle time, Order entry methods, Human resource productivity	Order entry methods, Human resource productivity
Source		Supplier delivery performance, supplier leadtime against industry norm, supplier pricing against market, Efficiency of purchase order cycle time, Efficiency of cash flow method, Supplier booking in procedures	Efficiency of purchase order cycle time, Supplier pricing against market
Make / Assemble	Range of products and services	Percentage of defects, Cost per operation hour, Capacity utilization, Utilization of economic order quantity	Percentage of Defects, Cost per operation hour, Human resource productivity index
Deliver	Flexibility of service system to meet customer needs, Effectiveness of enterprise distribution planning schedule	Flexibility of service system to meet customer needs, Effectiveness of enterprise distribution planning schedule, Effectiveness of delivery invoice methods, Percentage of finished goods in transit, Delivery reliability performance	Quality of delivered goods, On time delivery of goods, Effectiveness of delivery invoice methods, Number of faultless delivery notes invoiced, Percentage of urgente deliveries, Information richness in carrying out delivery, Delivery reliability performance

Table 3.2 – Supply Chain Performance Metrics Framework. Adapted from Gunasekaran, Patel & McGaughey (2004)

The authors mention that the framework may not apply to all supply chain industries, but may serve as a starting point. Below, the measures that are better applied to the scope of the project are explained:

- **The Order Entry Method:** "…the way and extent to which customers specifications are converted into information exchanged along the supply chain" (Gunasekaran, Patel & McGaughey, 2004);
- **Order Lead-Time:** "The total order cycle time, … , refers to the time elapsed in between the receipt of customer order until the delivery of finished goods to the customer"; "… important performance measure and source of competitive advantage…" (Gunasekaran, Patel & McGaughey, 2004);
- **Capacity utilization:** "… affects the speed of response to customer demand through its impact on flexibility, lead-time and deliverability" (Gunasekaran, Patel & McGaughey, 2004);
- **Effectiveness of scheduling techniques:** "Scheduling refers to the time or date on or by which activities are undertaken" (Gunasekaran, Patel & McGaughey, 2004);
- **Evaluation of delivery link:** "… primary determinant of customer satisfaction"; "… measuring and improving delivery is always desirable to increase competitiveness" (Gunasekaran, Patel & McGaughey, 2004).

Table 3.3 below presents the measures and metrics considered appropriate for the project. It is important to mention that this is the result from the combination of knowledge obtained from the literature and the previous experience of Company X. Their further application will depend on the company's strategy and the availability of data.

Dashboard Theme	Measure / Metric	Description	Observation
Systems Purchase Orders Information ________ **Operation Purchase Orders Information** ________	Measure	Number of Orders	
		Lead-Time	Elapsed time from the beginning of a process until its end (calculated using timestamps).
		Average Lead-Time	
		Number of orders that failed	Orders that did not achieve the proposed goal.

Transportation Purchase Orders Information __________ **Online Sales Supply Chain E2E Process Summary** __________ **Online Sales Supply Chain E2E Process Summary (Campaign Season)**		Number of successful orders	Orders that did achieve the proposed goal.
	Metric	Rate of success	Ratio between the number of successful orders and the total number of orders.
		Range of errors	Distribution of orders between all the registered process errors that are identified by a current or by a past status.
		Number of orders per worked hour	Orders completed divided by the total number of worked hours (consider number of employees).
Online Sales Supply Chain E2E Process Summary	Measure	Average Cost of Process	Should be per purchase order
	Metric	Range of Products and Services	Distribution of orders between product categories.
		Cost per worked hour	Appropriate when talking about the preparation process.

Table 3.3 – Measures and metrics defined for the project

When a measure or metric is based on orders, it may refer to the number of purchased orders, total number of units ordered (volume) or number of shipments (packages shipped). It depends on the process it needs to describe.

When referring to the preparation process (Operation), it is better to work with volume, since purchase orders may be split into different shipments. On the other hand, Transportation is mostly concerned about the number of shipments. They should be able to track each unit in the delivery process, but their performance should be based on the number of shipments. When it comes to Systems, this matter does not have a big influence. Although their teams need to make sure every unit is accounted for, measuring their performance by purchase order is more appropriate.

Finally, the overall E2E process should base its performance on the “smallest” element inside a purchase order (that cannot be separated). So, dealing with volume would be appropriate.

3.4. DATA MART CONCEPTUAL MODEL

After defining the prerequisites for the BI system and listing the appropriate measures and metrics for that purpose, the next step should be designing the data mart.

It is important to mention that the chosen denomination “data mart” is due to the fact that this multidimensional model focuses solely on the supply chain online sales operation and does not consider operations company wide.

Just as was mentioned in the previous section, a data mart model must be aligned with the companys needs and strategy. So, for a conceptual model that answers to companies other than Company X, it is only possible to define the core dimensions and fact tables. Also, most table fields are specific to the business and only the main ones will be presented in the model.

Therefore, the data mart model proposed in this section is not a complete version. It contains the core dimensions, fact tables, fields and granularity necessary to solve the problem proposed in this project.

The chosen methodology to design the data mart was the one presented by Kimball & Ross (2011) and is composed by four main steps: 1) Select the business process; 2) Define the granularity; 3) Identify the dimensions; 4) Identify the facts. The schema chosen was the fact constellation schema in which there are multiple fact tables that share dimensions between them.

3.4.1. Select the business process

The data mart model should be focused on the online sales supply chain E2E operation of a “clickand-mortar” or “pure-play” company.

As it was already presented in the “Overall Requirements” section, for this conceptual model to be adaptable, it is important to consider the overall process of an online sale and not the specific processes within each company. The five milestones of the process are: payment, integration, expedition, order pickup and delivery.

It is important to mention that one of the main requirements listed was that the model should provide the possibility to track each purchase from the moment it was created to the moment of delivery.

3.4.2. Define the granularity

By the word granularity, Kimball & Ross (2011) meant the level of detail associated with fact table measurements.

When dealing with online sales, it is common to think of an online purchase order as being the smallest grain and, consequently, use it to define the granularity of a fact table. However, online purchase orders may contain multiple units and items[2].

For the first milestone, payment, having a mono or a multi purchase order does not make a difference. All the units will be payed at the same time. Nevertheless, they may become available for preparation at different times and may not be delivered in the same shipment. Consequently, the remaining milestones' timestamps (integration, expedition, order pickup and delivery) are bound to be different between each unit within a purchase order. So, to deal with the overall E2E process, the appropriate would be to present the data at a unit level.

The same applies when the process is divided into: Systems, Preparation and Transportation. The teams responsible for Systems need to make sure that every unit within each order integrates in the appropriate system at the right time. Preparation, on the other hand, needs to secure the picking and packing of each unit made available for preparation (that integrated) in the system. Finally, Transportation needs to keep track of every shipment and to guarantee that every unit within them gets delivered at the right time and place to the customer.

Each unit of a purchase order is associated with specific timestamps that are related to a time dimension through their date part. It is also associated to a specific SKU (represents the product) and to a specific postal code (represents the delivery address). For an entire purchase order there would be a single flow type defined and, for a shipment, a single shipping company.

So, the granularity would be defined as online sale, per product, per day, per address, per flow, per shipping company, per unit within the purchase order. The grain would be one row per online sale

process. Different fact tables may not present all these listed attributes, but will all be developed on a unit level.

3.4.3. Identify the dimensions

From the previously defined granularity, it is possible to infer which will be the core dimensions. Still, it is important to mention that each company has its peculiarities and strategies, which may result in less or additional dimensions.

The hierarchies presented for some of the following dimensions (not all dimensions have a hierarchy) are also bound to change when adapted to other companies. For example, different companies may present different product hierarchies.

A final consideration concerns the management and storage of both historical and current data. Some dimensions' records, in specific fields, may change overtime. For example, a product name that was mistakenly registered needs to be corrected. In order for that to be a possibility, the dimension should

[2] An item is equivalent to a SKU while unit represents each article within a purchase order (multiple units may be of different or of the same SKU).

be configured as a slowly changing dimension (SCD) and the appropriate changing fields assigned. These SCDs can be of three different types: Type 1, Type 2 and Type 3.

a. Type 1 SCD: The new data overwrites the existing data, which results in the loss of what was previously stored;

b. Type 2 SCD: A new record is created to store the new data; additional fields may be used to track inactive and active records; this type of SCD provides the possibility to keep historical information;

c. Type 3 SCD: The use of two different columns allows for the original and the current data to be registered in the same record; however, if the record changes more than once, historical information is lost.

Even though it may result in the increase of the size of the table, Type 2 SCD was considered the most appropriate for the purpose of the model.

Below are presented the proposed dimensions for the data mart model. The suggested structures are presented in tables 9.1 through 9.7 in the Appendix section. The tables present both the fields and their descriptions.

- **Time Dimension:** This dimension was named **DimDate** and presents the dates between a determined period of time. Its hierarchy is composed by six levels: date, week, month, quarter, semester and year.

  Since one of the main purposes of this project is to develop a model that allows users to keep track of every order, being able to know the date and the time when every milestone is achieved is essential. However, it is not viable to have a dimension that keeps track of hours and minutes. So, DimDate will only be related to keys that are defined by the date part of the timestamps. The timestamps, on the other hand, will be presented in separate fields in the fact tables.

  It is also important to mention that, when dealing with an online sale E2E process, holidays, weekends and changes of season can have a big impact. These may result in peaks of sale or even in the lack of human resources in the preparation process. Even though these behaviors and trends and very specific to each business, fields were included in the conceptual model dimension that describe them.

- **Product Dimension:** This dimension was named **DimProduct** and presents the entire range of products that are or were available for sale in the company. Some of these products may not even share the same online sales overall E2E process and are not going to be represented in any fact table.

  However, in order for this conceptual model to be able to incorporate other processes in the future and, consequently, other fact tables, it is important not to limit the product dimension. For example, as it was mentioned in the "Context" section, the model only focuses in Company X's online sales of small and medium formats, since large formats undergo a much different process and cannot be presented in the same fact tables. Still, in the future, it can be of interest to expand the data mart.

Also, the products in the dimension may be active or inactive (available or not for sale). This will be identified by a specific field, which can be altered overtime. Besides the product status, other fields in the dimension may go through changes. These are the product supplier name and number, the standard cost and the list price. For these changes to be a possibility, the dimension should be configured as a SCD and the appropriate type chosen. Since keeping historical data is of interest, this SCD was designed as type 2 with two additional datetime fields to track the start and end moment of the record being active.

It is important to mention that each company will have a different product hierarchy and the one shown in Table 9.2 in the Appendix is only a reflection of the previous experience with Company X.

- **Address Dimension:** This dimension was named **DimAddress** and presents all the locations that can either be customers', warehouses' or stores' addresses. In order to define which one it is, a field was be used to identify the type.

  Since the same postal code can be shared by different types of addresses, it cannot be used as the primary key. So, a separate field was created for the postal code.

  The hierarchy defined for this dimension can be observed in Table 9.3 in the Appendix, as well as the other fields.

- **Flow dimension:** This dimension was named **DimFlow** and presents, in a simplified way, all the possible flows that a certain unit within a purchase order can go through. These flows are going to be very specific to each company.

  When it comes to Company X, having a clear perception of the flows is essential. Its flows were explained in the "Context" section of the chapter and reflect the site of preparation, chosen shipping company and final place of delivery. Once there are many possible combinations of these three elements, adopting this dimension in the model adds value to the user's experience.

  Since changes in specific processes may occur overtime, the flows presented in this dimension cannot be said to be static. For example, Company X can decide not to work with a certain shipping company or even to concentrate the entire preparation process in the warehouse. This would turn active flows into inactive. Other companies are also subject to changes. So, to configure this dimension as a SCD was considered the most appropriate. The changing field would be the flow status.

- **Shipping Company Dimension:** This dimension was named **DimShipCompany** and presents all the shipping companies responsible for the pickup and delivery of every ongoing order within the company. In order not to limit the model so it can be expanded to other processes, it is not interesting to present only shipping companies involved in the fulfillment of online orders. On the contrary, and alike DimProduct, the dimension should be as complete as possible.

  Also, the dimension was configured as a SCD with its changing fields being the shipping company status and pickup frequency. The first field shows if the shipping company is active or not, meaning if its services are still being required. Similarly, if there are ever any revisions in the contract, the second field may go through changes.

It is important to mention that, depending on the company's strategy, it may choose not to rely on outsourcing to handle deliveries. In this case, a shipping company dimension is not needed.

- **Store Dimension:** This dimension was named **DimStore** and presents all the stores, both physical and online, ran by the company. Considering it only has one online store, this dimension only makes sense if there are other physical stores to be listed. So, it can only be applied to "click-andmortar" businesses.

  When considering Company X, for example, a dimension focused on stores may give details concerning where the sale was made (if it was in a store with a SA or directly online by the customer).

  Alike the previous dimension, DimStore is a SCD with the store status and the number of employees being the changing fields.

- **Status Dimension:** This dimension was named **DimStatus** and presents all the possible statuses a purchase order unit can go through from the moment of creation until the moment of delivery. This dimension contains a field focused on the process the status describes, which can be either the overall E2E process, Systems, Operation or Transportation.

3.4.4. Identify the facts

The last step, proposed by Kimball & Ross (2011), in the process of designing a data mart, is to identify the facts.

In order to achieve one of the main requirements for this model, the facts defined should provide the possibility to track each purchase order from the moment it was created until the moment of delivery. This consists of a process that needs to be presented in a single fact table with milestones timestamps that are updated overtime.

The data mart model also needs to support the individual teams responsible for Systems, Operation and Transportation. Their performance evaluation depends on the analysis of the elapsed time of their operations. Consequently, recording each timestamp as they are updated overtime is essential.

Since Systems, Operation and Transportation are all part of the same overall E2E process, one could think that a single fact table would be enough to manage the entire online sales process. However, each one of the groups has its own specificities and may require specific fields to address the needs of their teams. So, in order to avoid working with a single large fact table, the appropriate would be to concentrate specific fields on fact tables designed to the specific parts/groups of the online sales E2E process.

This would result in a data mart model composed by four fact tables. Three fact tables would be focused on the specific parts of the process (Systems, Operation and Transportation). The table fields would then reflect the needs of the teams and could even contain a more detailed view of the specific processes that occur within each of these groups.

A final fact table would then be focused on the overall online sales E2E process. Its purpose would be to track each unit within each online purchase order from the moment it was created until the moment of delivery and assess the overall performance. Most of its fields would be composed of milestones timestamps. The remaining fields would provide a more detailed view of the overall E2E process, as well as measures and surrogate keys that are related to the dimensions.

Since we are dealing with processes, in this case the online sales pipeline, the best way to represent it would be as a time stamped accumulating snapshot fact table. According to Mundy (2012), a standard accumulating snapshot fact table may be characterized by one row per occurrence of the process and each of these rows is updated multiple times until the pipeline is somehow completed. The author presents it as an appropriate solution to track the current state of a particular process, but states that it is imperfect when it comes to keeping record of intermediate states (such as processes' statuses) (Mundy, 2012).

One of the solutions presented by Mundy (2012) involves the combination of two types of fact tables: an accumulating snapshot with a periodic snapshot. The resulting fact table would be similar to a type 2 dimension with two additional fields: the first one would be a snapshot start date (when the row became effective) and the second one a snapshot end date (when the row expired). So, every time something in the pipeline changes, a new row is added with the updated fields. The snapshot start and end dates of the original and the current records are also updated accordingly (Mundy, 2012).

Another challenge faced in the definition of the fact tables was when dealing with the primary keys. In most situations, the combination of the dimensions' surrogate keys would be enough to obtain the primary key. However, this is not the case for the present model. Since each record of a fact table represents a single unit of a purchase order, it can be related to its business ID, which should be unique in all data sources in the company. If no historical data is being kept int the fact table, this business ID would be enough to achieve a unique primary key for the model.

According to Becker (2003), this would be called a degenerate dimension (DD).The author states that a DD "acts as a dimension key in the fact table , however does not join to a corresponding dimension table because all its interesting attributes have already been placed in another analytic dimensions" (Becker, 2003). He also mentions that these DD are usually "natural keys of the "parents" of the line items" (Becker, 2003).

Nevertheless, since it is considered appropriate to keep historical data, each fact table gains a new record every time there is a change in the unit's pipeline. So, a purchase order unit business ID used as a DD is no longer acceptable to maintain unique primary keys.

An appropriate way to overcome this would be through the combination of the unit business ID with the snapshot start date. Another option would be through the creation of a separate field that combines the unit business ID with the number of times the pipeline of the same purchase order unit has changed (number of rows created to register the changes).

DDs are also useful when dealing with data quality and integrity, since they allow records to be traced back to their original operational systems. A fact table may have more than one DD as well. For example, purchase order number and purchase order unit number may be both DDs in a fact table.

It is important to mention that, since many of the fact table fields associated to dimensions are updated overtime and may not have initial values, the dimensions must contain default values such as "unknown" or "n/a". This happens because a key value in a fact table cannot be null. For example, all dates after the creation of a purchase order do not have initial values. Consequently, for these dates to relate to a dimension before being updated, a default value is necessary.

Tables 9.8 through 9.11 in the Appendix propose a structure for the data mart's fact tables. They present both table fields and their descriptions. Since every company has its own specifications, these structures should be adapted to fit its own business scenarios and processes.

Below, a simplified version of the diagram of the conceptual data mart model is presented. The complete version of the diagram is shown on Figure 9.1 of the Appendix. Also, in order to make the visualization easier, diagrams focusing on single fact tables and their respective dimensions are presented in the Appendix (Figure 9.2 through Figure 9.5).

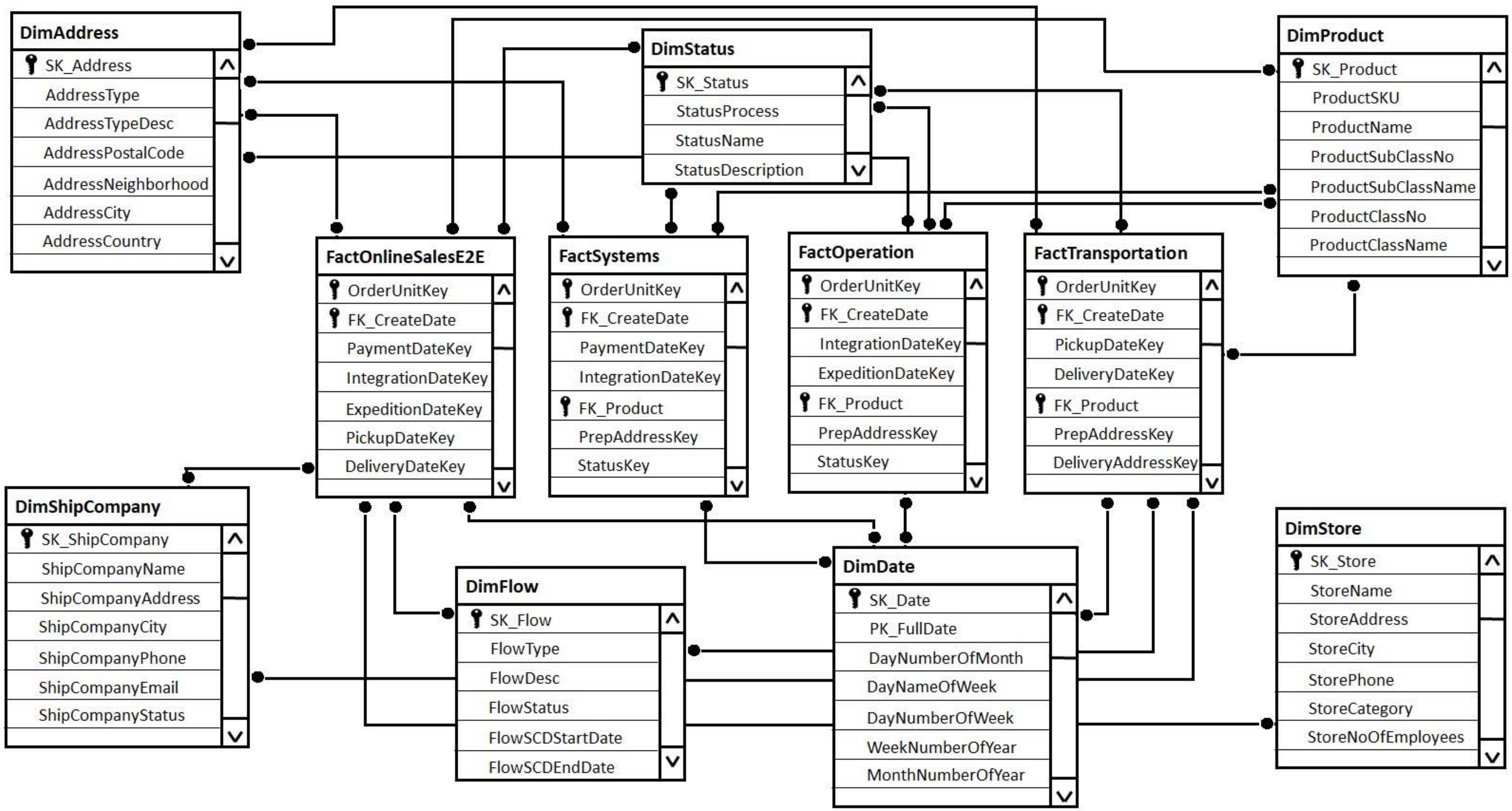


Figure 3.5 – Simplified diagram of the conceptual data mart model

3.5. Dashboard Conceptual Model

Following the proposed goals and objectives of this project, a conceptual model was developed for the final dashboards.

Like in the previous topics, it is important to note that a BI system should be specific and aligned with the company's strategy. So, the conceptual model proposed in this chapter is only a suggestion of a solution for problems that are similar to Company X's.

Not only the structure of the dashboards but also the measures, metrics and KPIs presented in them may vary from one company to the other. Even though a list of appropriate measures and metrics was presented in topic 3.3, a company may lack the data that is needed to obtain them. Consequently, the dashboards' models presented below may be subject to change when considering certain scenarios.

As it was already mentioned in the "Measures and Metrics" topic, five dashboard themes were proposed with different levels of information. At an operational and tactical level, the themes were: 1) Systems Purchase Orders Information; 2) Operation Purchase Orders Information; 3) Transportation Purchase Orders Information; 4) Online Sales Supply Chain E2E Process Summary (Campaign Season). At a tactical and strategic level, the theme was: 1) Online Sales Supply Chain E2E Process Summary.

The dashboard models presented below were designed based on the best practices identified in the researched literature. They intend to present the information in an efficient, yet coherent, way.

Following the dashboard design technique proposed by Janes, Sillitti & Succi (2013), it is possible to observe that the first step (select the proper data to extract) was completed in section 3.3. With the goals previously defined, the right questions were asked and the appropriate measures defined. For the next step, it was then necessary to choose the proper visualization. The authors' observations were taken into account as well as Abela's (2006) guidelines to choose appropriate charts.

Finally, the distribution of these charts was considered. Combining the theory provided by Bakusevych (2018) and the reading gravity chart by Reporting Impulse (2019), the optimal visualization areas were identified. Even though the authors' guidelines provide a path for the dashboards' design, each one of them should be specific to the business needs. So, variations may exist when applied in real life scenarios.

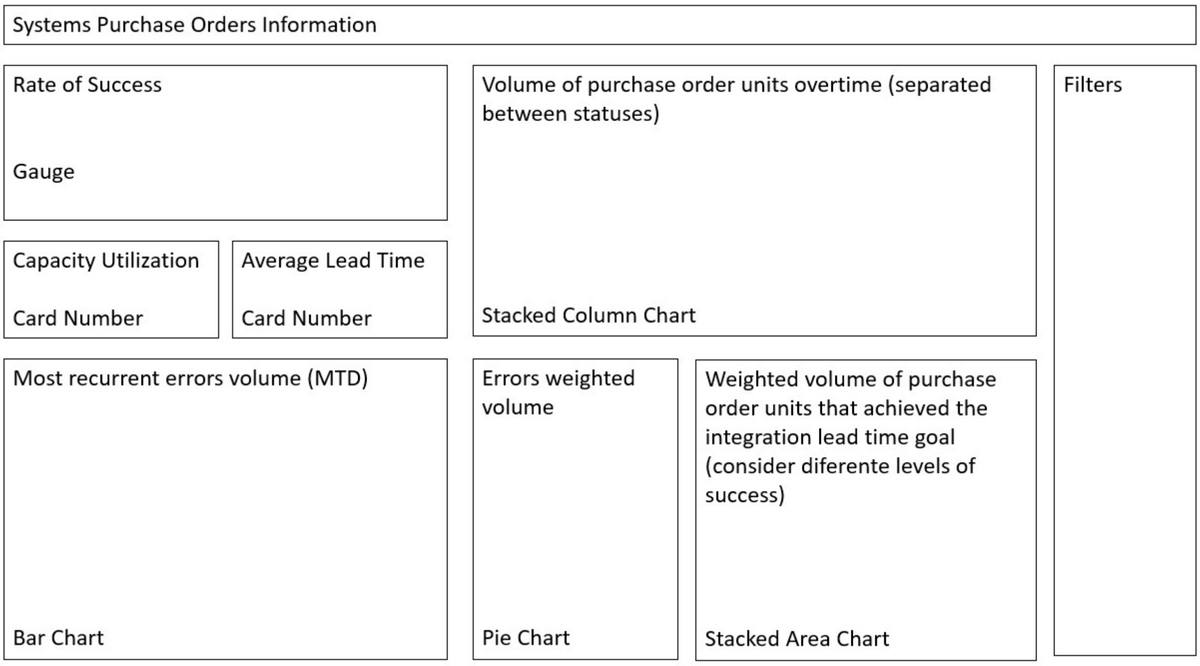


Figure 3.6 – Systems Purchase Orders Information dashboard conceptual model

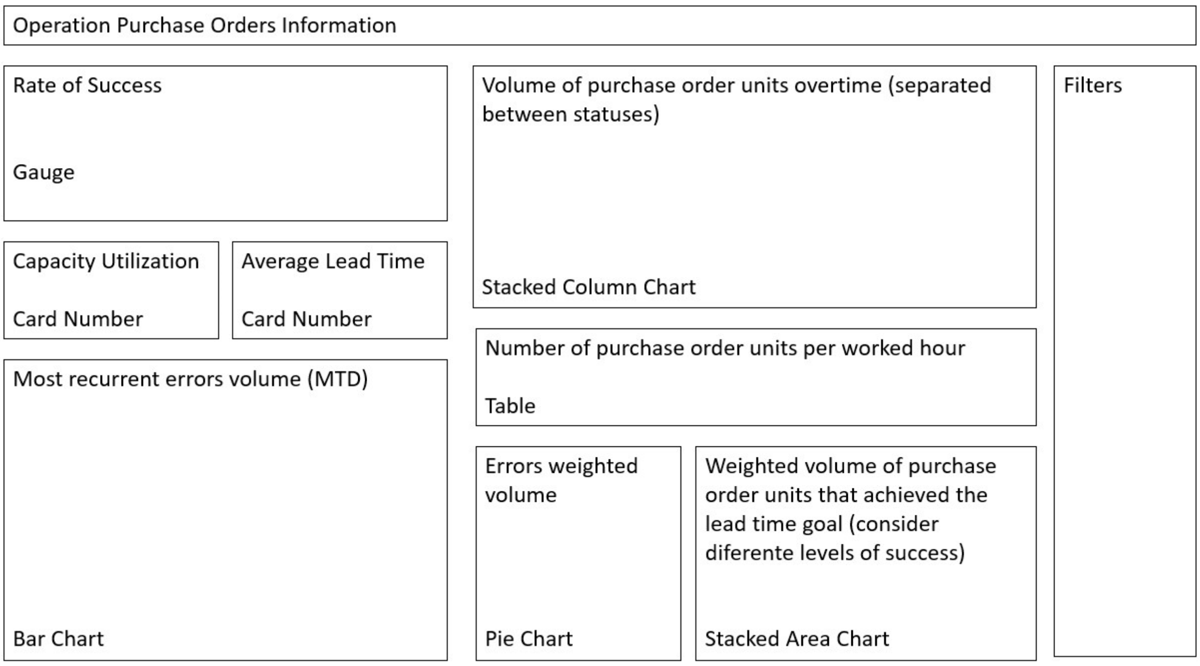


Figure 3.7 – Operation Purchase Orders Information dashboard conceptual model

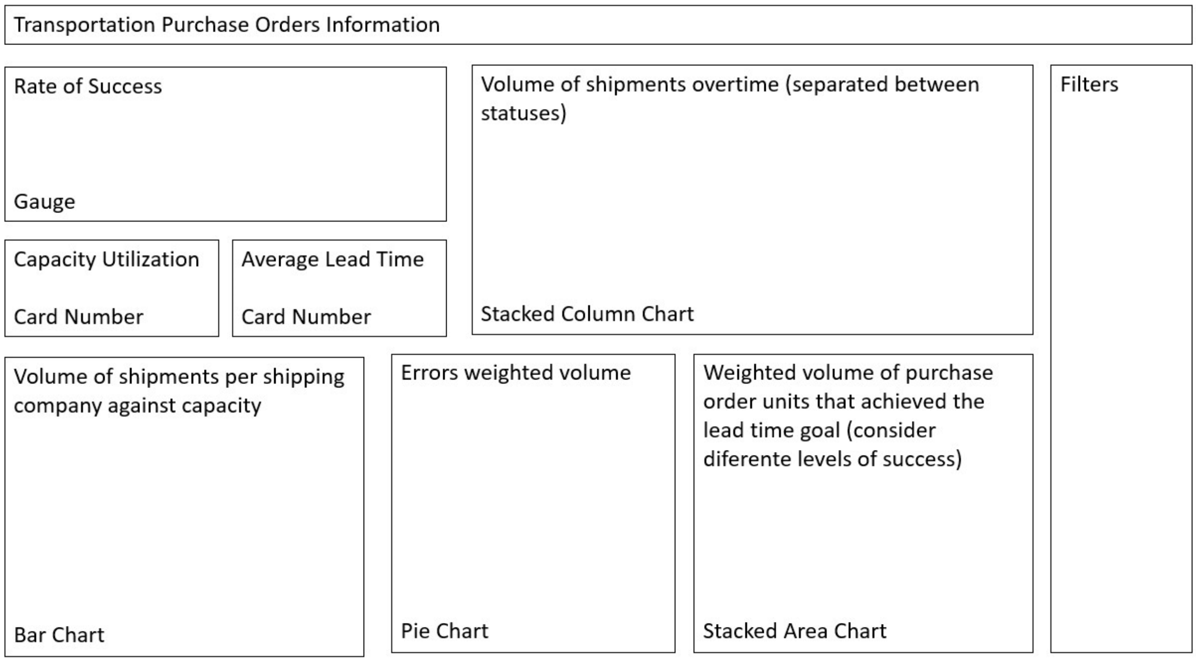


Figure 3.8 – Transportation Purchase Orders Information dashboard conceptual model

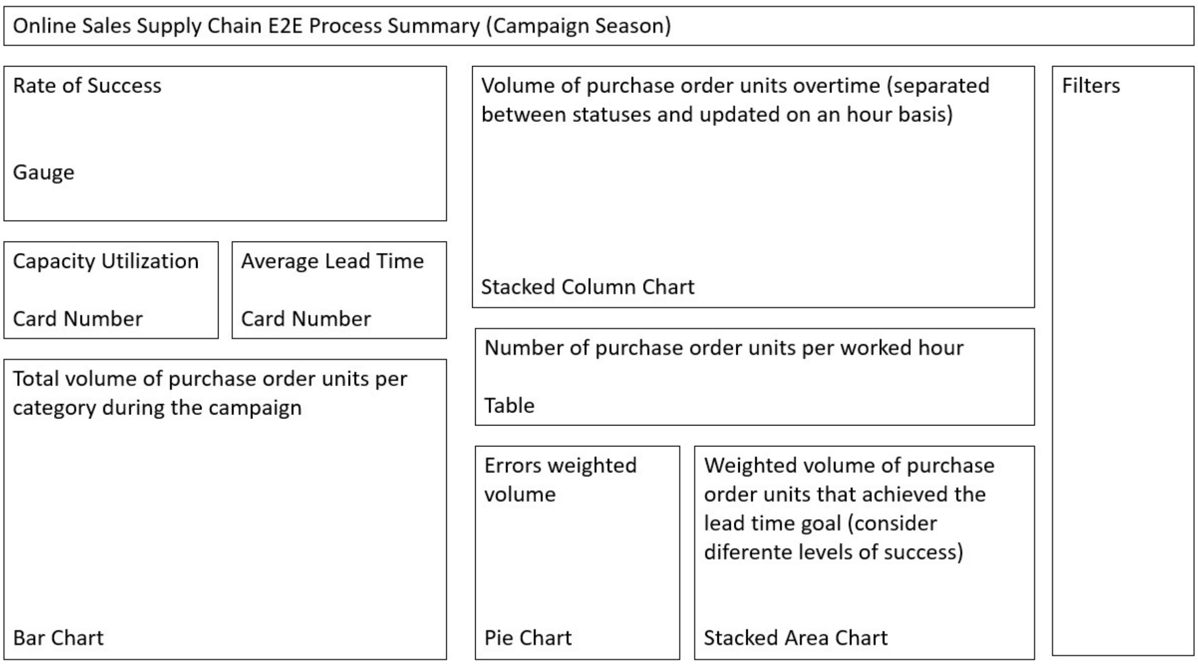


Figure 3.9 – Online Sales Supply Chain E2E Process Summary (Campaign Season) dashboard conceptual model

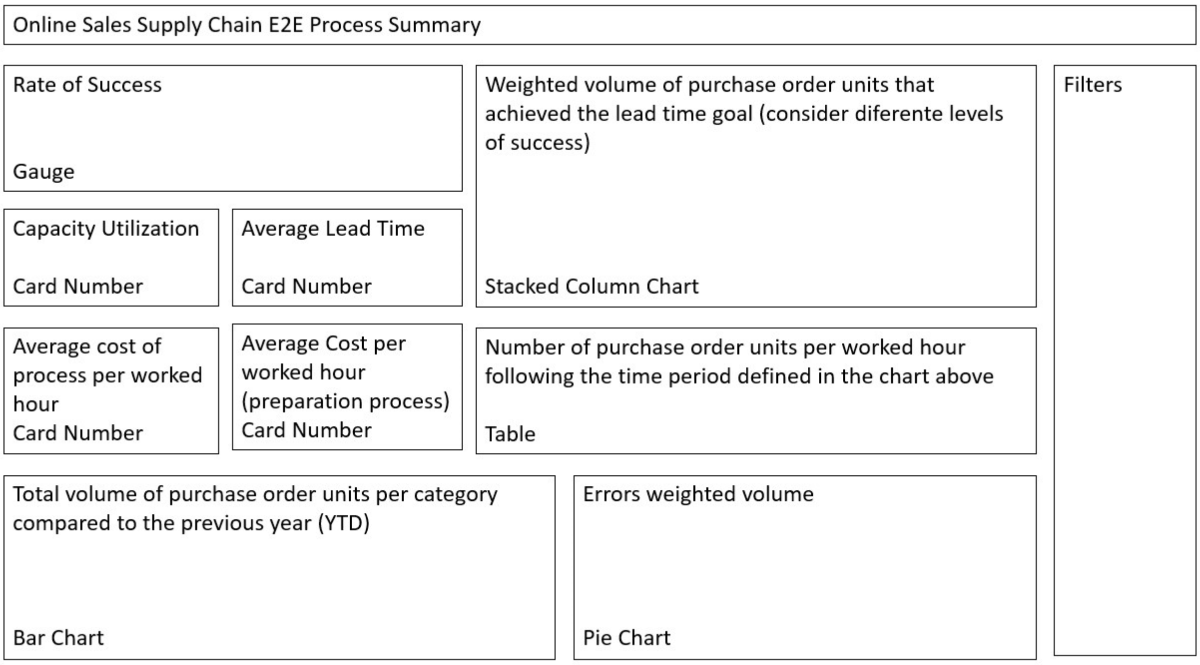


Figure 3.10 – Online Sales Supply Chain E2E Process Summary dashboard conceptual model

4. DEVELOPMENT

This chapter consists of the "Demonstration" step proposed in the DSR methodology. It intends to develop a case study through the application of the previously proposed model to solve Company X's data related needs.

First, a study will be conducted in order to identify the most appropriate tools to implement the proposed BI system. Next, the identification and contextualization of the company's data sources will be done, followed by the adaptation of the proposed data mart model to fit Company X's reality and the implementation of the ETL process. Finally, the dashboards will be presented.

4.1. PLATFORM

The definition of the most appropriate tools to implement the BI system proposed in the previous chapter was done based not only in a Gartner's study, but also in Company X's available resources.

According to the research released by Gartner in the year 2020, Microsoft BI platforms are placed in the "Leaders" quadrant as the ones that present the most completeness of vision and ability to execute. The research was based in the capabilities and features provided by the different BI platforms available in the market. Figure 4.1 below shows the graphic that was published by Gartner as result of the study:

Figure 4.1 – Magic Quadrant for Analytics and Business Intelligence Platforms (Gartner, 2020)

In order to achieve the purposes of the project, the chosen software was: Microsoft SQL Server and Power BI, both developed by Microsoft and available for use in Company X. More specifically, SQL Server Management Studio (SSMS) and SQL Server Integration Services (SSIS) were the components chosen from Microsoft SQL Server database software to implement the data integration, processing and loading stages of the project. On the other hand, Power BI was defined as the reporting platform, where the final dashboards are supposed to be designed and managed.

A brief description of the chosen tools is provided below:

- **SSMS**: As stated by Esat Erkec (2020), SSMS "is an advanced, development environment that enables us to configure, manage and administrate SQL Server database engines". One of its central features is "Object Explorer" that allows users to manage objects within Database Engine, Analysis Services, Integration Services and Reporting Services, which are instances of Microsoft SQL Server (SQL Docs, 2017). For example, it is possible to schedule through SSMS the deployment of packages within the Integration Services Server and that are stored in SQL Server (SQL Docs, 2018).

- **SSIS**: Another component of Microsoft SQL Server, SSIS is a platform used to build "enterprise-level data integration and data transformation solutions" (SQL Docs, 2018). When it comes to this project, Integration Services was the tool chosen to develop the ETL process. Through SSIS, it is possible to extract data from a wide range of data sources, to perform the necessary data transformations and to load it into the chosen destinations.

- **Power BI**: It is a business analytics solution that allows the user to visualize data and collaborate with insights to a better informed decision making process (Power BI, 2020). The user is able to connect to different data sources and to explore it, resulting in interactive visualizations, dashboards and reports. These can be published and shared across the organization. In the current project, Power BI is used as a reporting tool, in the development of dashboards, since it is not only positioned as a leader in the Gartner Group study, but is also an available resource at Company X.

4.2. DATA SOURCES

The data necessary to implement the proposed BI system is not provided by a single source. Instead, it needs to be extracted from different data sources, of different types, transformed and integrated.

It is important to mention that Company X's available data does not allow for a complete implementation of the proposed data mart. So, for this case study, the conceptual model will provide guidelines for Company X's BI system, but changes will have to be made to adapt the model to the company's available data.

The following data sources were identified:

- **Online Management System (OMS)**: System responsible for maintaining data that concerns the online sales of Company X. Still, it does not provide all the required data, specially when it comes to Operation and Transportation. In OMS, all sales and sold units are identified, the corresponding products, customers, addresses and some important dates. It is also responsible for holding all data concerning supplier stores. All used tables and respective fields are identified in table 9.12 of the Appendix.

- **Warehouse Management System (WMS)**: System responsible for maintaining data that concerns all warehouse operations. For the current project, this is the system that will provide data on Operation for all online sales prepared in the warehouse. It is also responsible for defining the appropriate Shipping Company and it keeps record of Shipping Company Z's activities. All used tables and respective fields are identified in table 9.13 of the Appendix.

- **Retail Merchandise Operation System (RMOS)**: This was the first system to ever be implemented in Company X. It keeps data on various operations across the company. When it comes to the present project, RMOS helps identify all online sales that did not have their payment completed. It also provides the necessary data to complete the product dimension. All used tables and respective fields are identified in table 9.14 of the Appendix.

- **Longtail Excel File**: Every week (monday morning), the supply chain BI team receives an email containing an excel file with a list of all current longtails. An explanation for what longtails are was provided in the "Context" section of the "Conceptual Model Proposal" chapter. From the supplied spreadsheet, the only needed fields are: Year, Week and SKU.

- **Shipping Company Y Excel File**: An Excel file is provided daily (every morning) by Shipping Company Y containing data on their Transportation operation for the past months. It identifies tracking numbers, statuses and dates for all packages handled. The milestones of their transportation process are: 1) Picked up from Company X's warehouse, 2) Checked-in in Shipping Company Y's distribution center, 3) Left Shipping Company Y's distribution Center and 4) Delivered at customer's chosen address.

Due to the confidentiality agreement, the data sources' original structures, table names and field names cannot be presented. Instead, fictitious names were used to define the required tables and table fields for the ETL process. Also, generic names were used for each of the data sources.

4.3. DATA INTEGRATION AND PROCESSING

After defining which software is going to be used and identifying the data sources, the next steps in the implementation stage of the project are: to integrate the data, to perform the necessary transformations and to load it into the data mart. First, based on the proposed data mart conceptual model, the final data mart model for Company X is going to be presented. Then, the ETL process is going to be developed.

4.3.1. Data Mart Model

This section of the "Development" chapter is based on the implementation of the previously proposed data mart conceptual model to fit Company X´s scenario. As it was previously stated, the conceptual model did not solely focus on Company X. Instead, it was meant to provide a BI solution for all companies facing similar challenges. Consequently, the proposed fact tables and dimensions and respective fields should be adapted to fit Company X´s reality.

According to the data mart conceptual model, appropriate dimensions would be the following: DimDate, DimProduct, DimAddress, DimFlow, DimShipCompany, DimStore and DimStatus. Due to the lack of data, not all proposed data fields can be kept, as well as dimension DimShipCompany. A revised structure for all dimensions, the corresponding data types for their columns and necessary data sources are presented in Table 9.15 through Table 9.20 in the “Appendix”.

The conceptual model also proposes the appropriate fact tables for this solution. They are the following: FactOnlineSalesE2E, FactSystems, FactOperation and FactTransportation. The first one is focused on the overall online sales E2E process. The other three, on the other hand, focus on the specific parts of the process (Systems, Operation and Transportation). Even though they are all appropriate as part of this BI solution, not all fields and tables may be implemented on Company X since some of the necessary data is not provided.

Due to the lack of data on Systems, this fact table does not integrate Company X’s data mart. Operation also lacks data on specific processes dates and statuses. The query provided to extract data from WMS does not contain that information. After adjusting FactOperation fields, the final fact table does not contain any complimentary data when compared to FactOnlineSalesE2E. So, it should not take part in Company X’s BI system. All the others may be implemented with some adjustments of the table fields. Table 9.21 and Table 9.22 in the “Appendix” present their final structure, respective data types and corresponding data sources.

As a result of the challenges faced in the ETL process (explained in the next section), implementing fact tables with a similar structure of a Type 2 SCD was not possible. Instead, a Type 1 like structure was adopted, meaning that only one record per unit is maintained and any changes end up overwriting previous fields. It also resulted in a change of the fact table keys, which became a concatenated version of the Order Unit Number and the Product Key.

It is important to mention that for Shipping Company Z it is not possible to obtain the ShippingCenterEntranceDate, as well as the OutForDeliveryDate. Also, the data mart model developed for Company X contains both TrackingNumber and AggregationTrackingNumber, as described in the “Context” section of the conceptual model proposal. Last, but not least, since the Madeira and Açores islands have extended shipping and delivery objectives, it is of interest for them to be identified.

Below, a simplified version of the diagram of the final data mart is presented. The complete version is shown on Figure 9.6 of the Appendix.

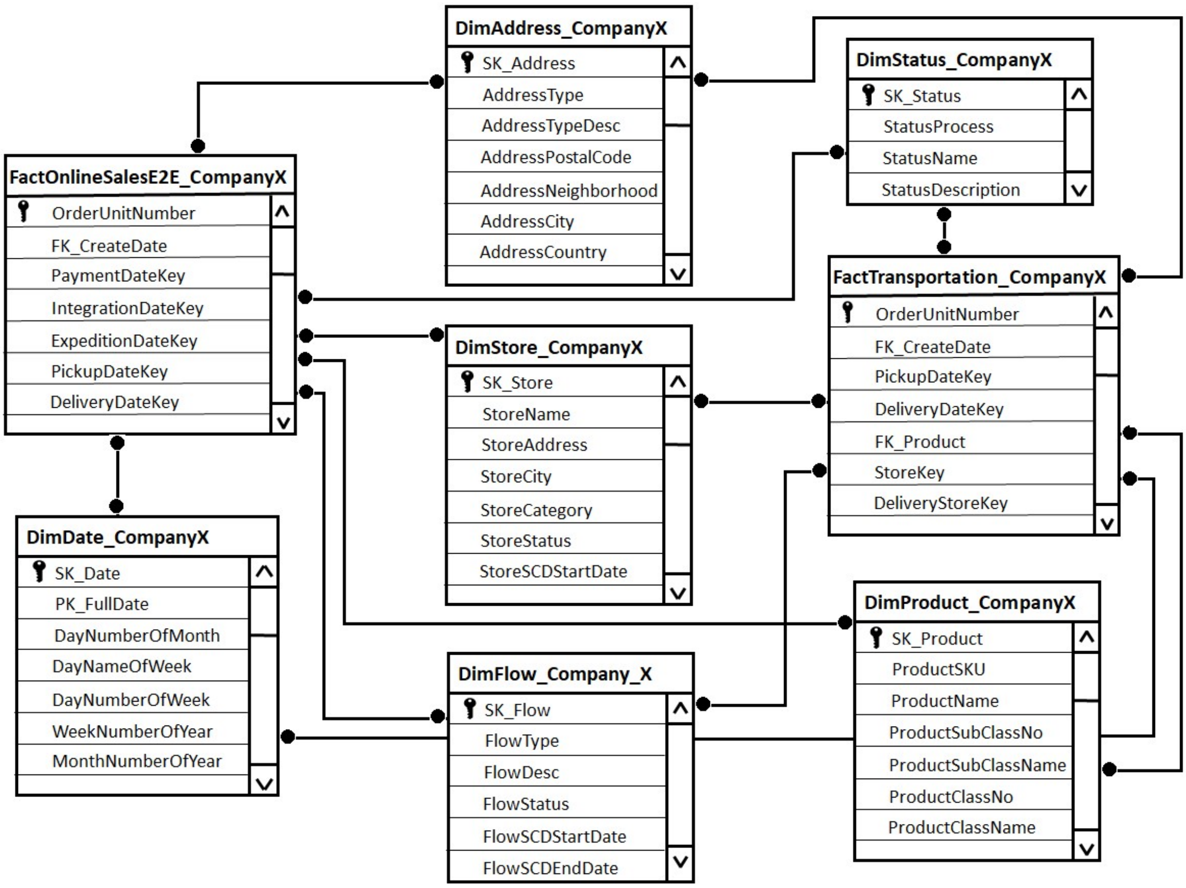


Figure 4.2 – Simplified diagram of Company X's data mart

4.3.2. ETL

After defining the data mart structure, the ETL process had to be implemented. Data from the previously presented data sources was first imported into a staging area. Then, in a second staging area, the data went through the necessary transformations in order to fit into the final data mart structure. Only then the data could be loaded into Company X's data mart.

The ETL process represented one of the most challenging parts of this project. Besides dealing with many data sources and with large volumes of data, it was necessary to implement the process using a computer that lacked the computing capabilities needed to do so. At first, only one staging area was used. However, when deploying the package in SSIS, there were often memory errors and, even when no issues were presented, it took so long to run the package that it became impracticable to use it as a solution.

There was then a second attempt, this time using two staging areas. The first one would be used mainly to import data from the multiple data sources. The second one, on the other hand, would store the data with all the transformations needed to make it appropriate for the final data mart. Although this solution solved the memory errors, it was still time consuming to deploy the packages (took over four hours to be completed). It is important to remember that, in campaign periods, the updates should be done every hour. So, for scheduled overnight updates, in an everyday scenario, this solution would be appropriate. However, while the updates are still manually done and are required on an hour basis, this solution is impracticable.

It is also important to consider that the implementation of this BI solution happened right after the change of the system responsible for managing the warehouse operations. So, besides representing a major change in the data sources field mapping, it became of great urgency to present the solution. Due to the fact that this project was developed in this scenario, there was no available time to pursue other optimization solutions.

Thus, to make the daily/hourly update a possibility, some adaptations had to be made. First, it was decided that the dimensions update would not be done every day, since no big changes are expected. Instead, the update would be done once a week.

Also, as it was already mentioned in the “Data Mart Model” section, a Type 1 SCD like structure was adopted for the fact tables, unlike what was proposed in the conceptual model. This new structure allowed the incremental load of the records to be developed, as well as the continuous update of the fields, since the milestones dates are only updated overtime.

Figure 9.7 through Figure 9.9 in the “Appendix” present a diagram with a summary of the ETL process developed.

4.4. DASHBOARD

The final stage of the implementation part of the project was the development of the dashboards. As it was already mentioned, the following dashboards should be designed based on the proposed structures of the conceptual model. Even though that was considered the best solution for the presented problem, it should fit into Company X’s reality, meaning that some adaptations are needed in order to implement it.

As seen in the previous sections, at the moment, Company X does not provide specific data concerning Systems and Operation. Besides that, data regarding costs and employees’ productivity is also not available. Consequently, the following dashboards were the ones implemented (with minor alterations): Transportation Purchase Orders Information, Online Sales Supply Chain E2E Process Summary (Campaign Season) and Online Sales Supply Chain E2E Process Summary. In order to present an overview of Systems and Operation performance, a fourth dashboard was built considering their milestones and their expected individual response times.

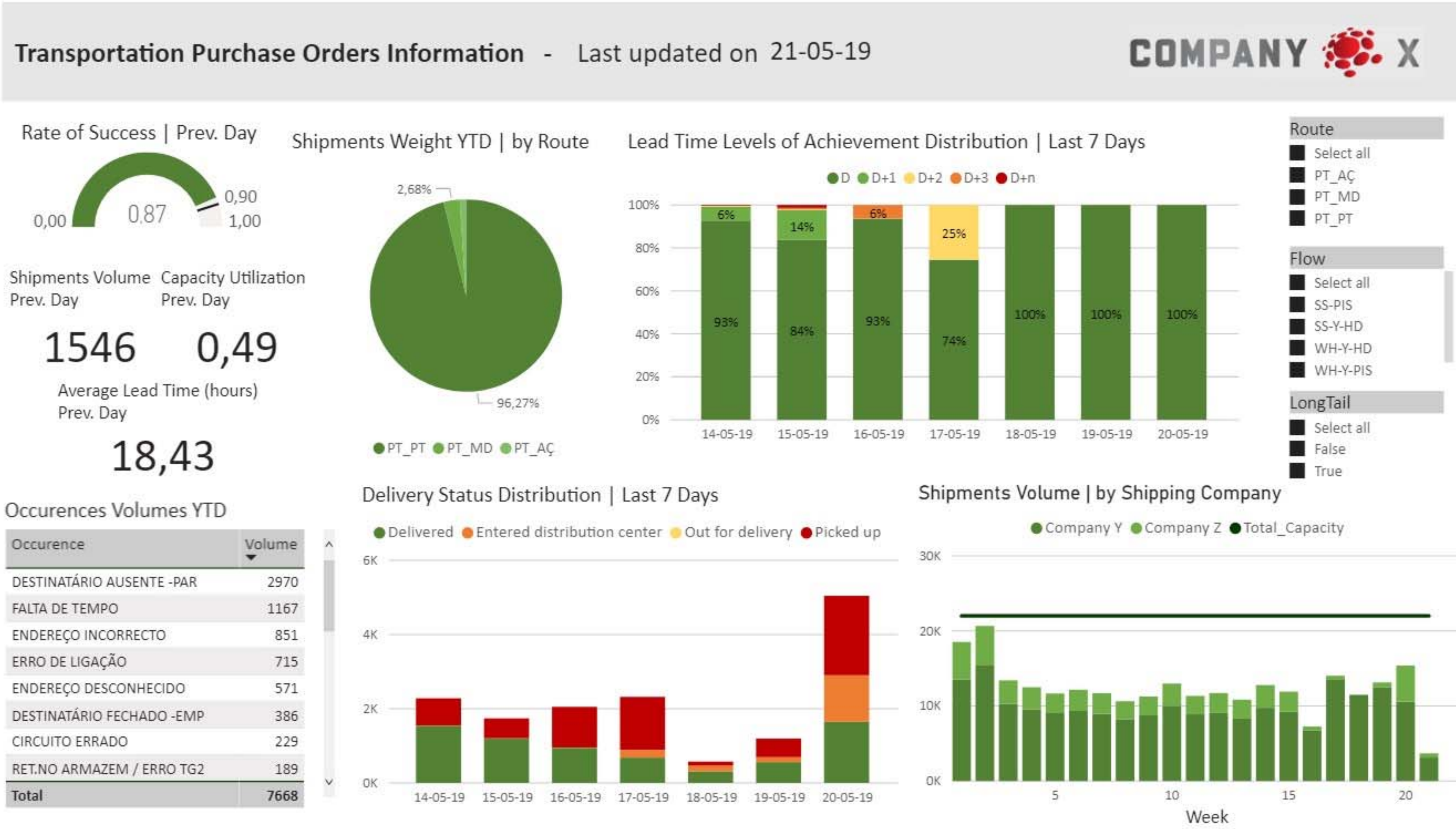
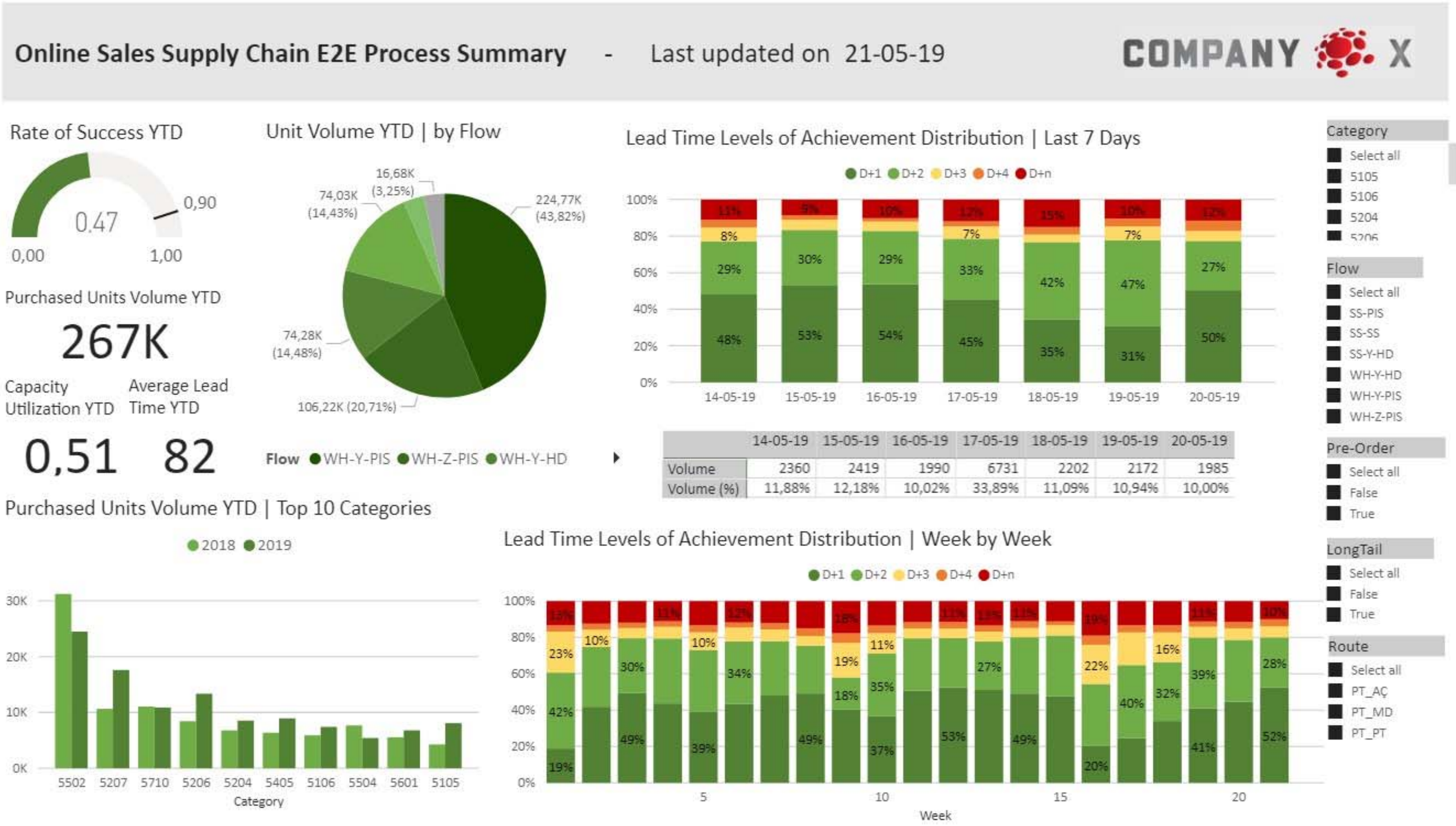


Figure 4.3 – Dashboard Transportation Purchase Orders Information



	14-05-19	15-05-19	16-05-19	17-05-19	18-05-19	19-05-19	20-05-19
Volume	2360	2419	1990	6731	2202	2172	1985
Volume (%)	11,88%	12,18%	10,02%	33,89%	11,09%	10,94%	10,00%

Figure 4.4 – Dashboard Online Sales Supply Chain E2E Process Summary

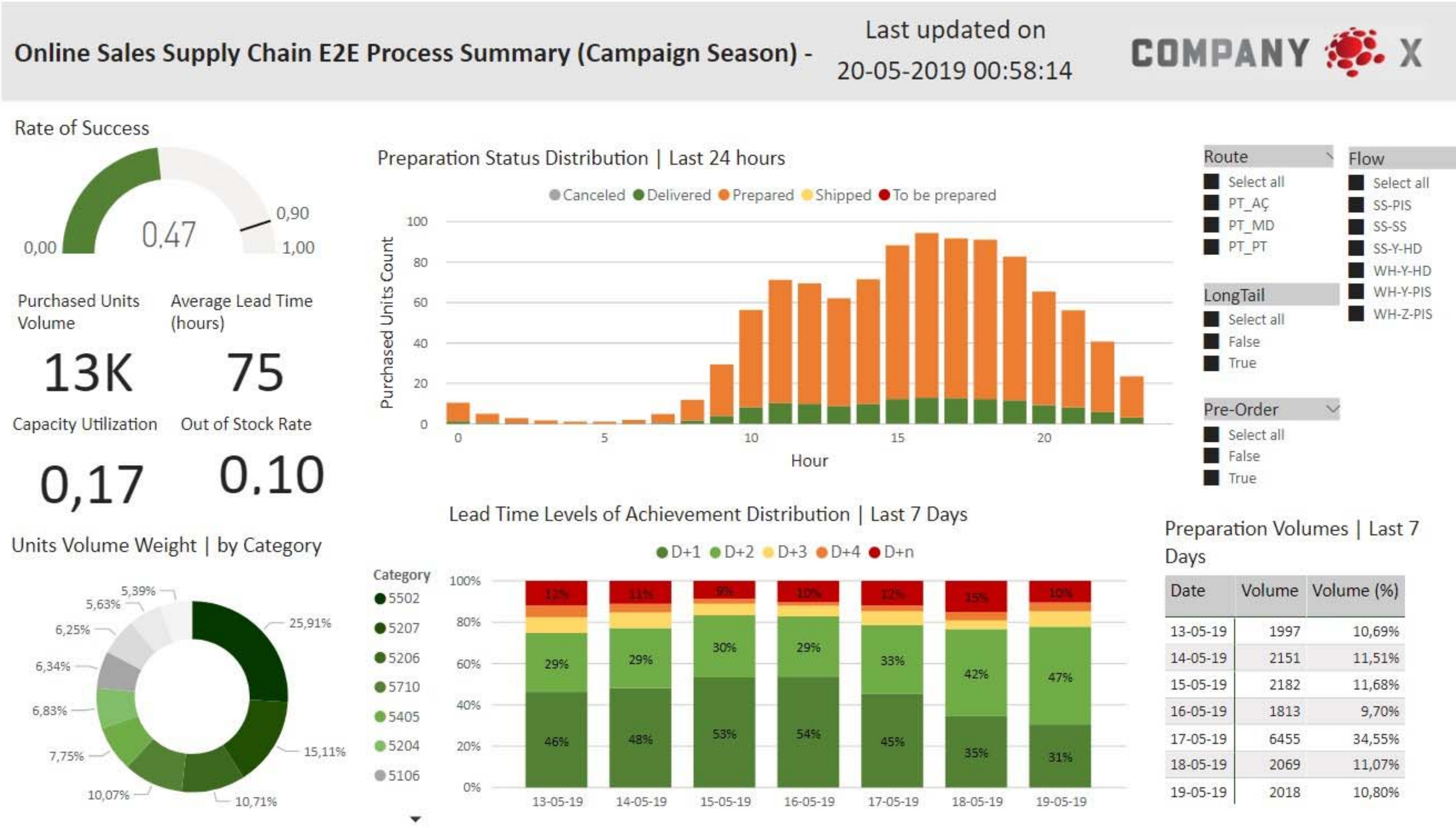


Figure 4.5 – Dashboard Online Sales Supply Chain E2E Process Summary (Campaign Season)

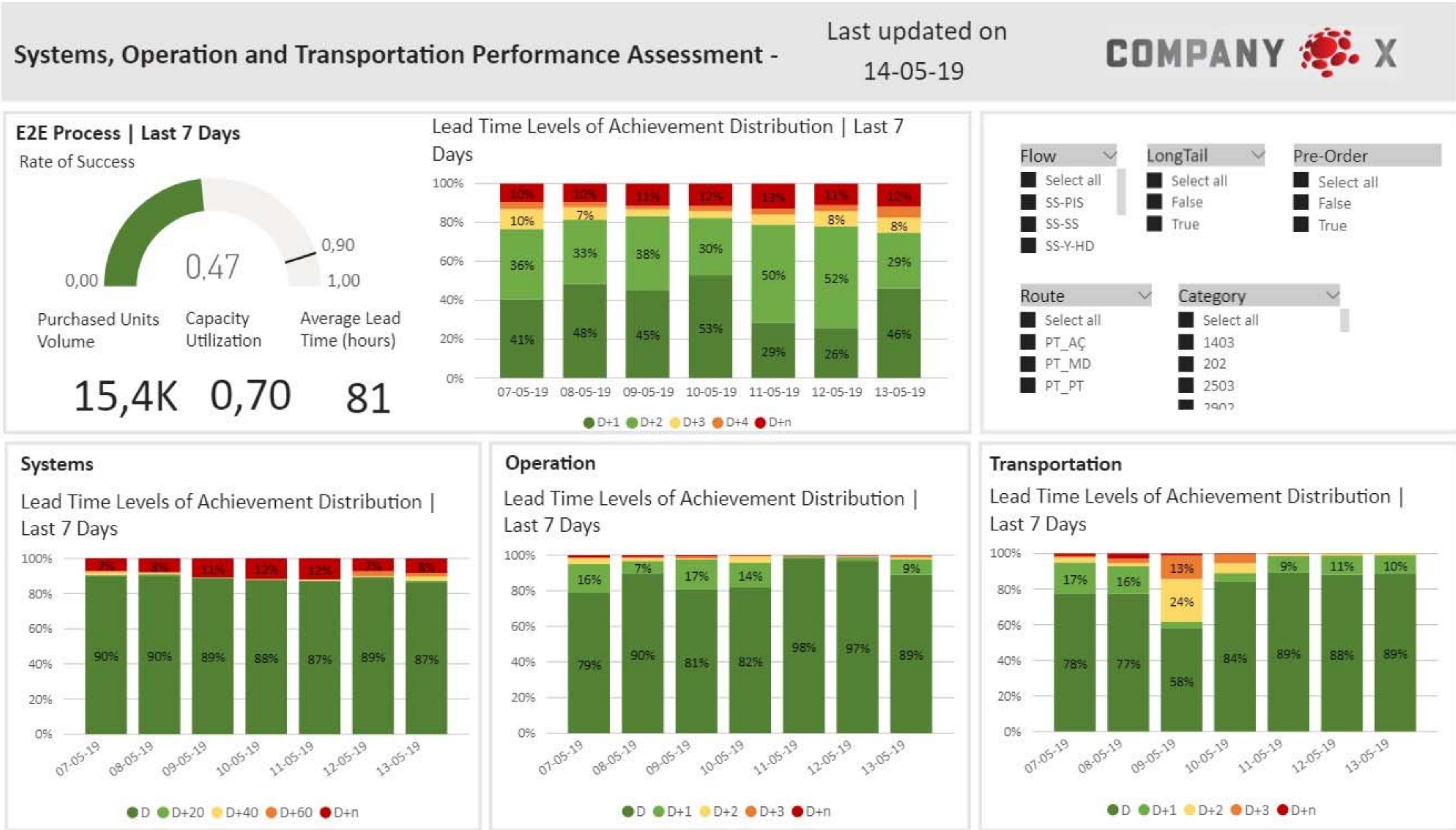


Figure 4.6 – Dashboard Systems, Operation and Transportation Performance Assessmen

Below, an explanation is presented for each of the implemented dashboards. The purpose is to understand what information is displayed and how it fits into the company's business scenario.

4.4.1. Transportation Purchase Orders Information

The first dashboard built was meant to provide information concerning Transportation and it is shown on Figure 4.3 of the previous chapter. The information provided is mostly on an operation level and is deeply focused on the context provided by Company X.

On the top left corner of the dashboard, a gauge visualization of the rate of success alongside three data cards containing information of the volume of shipments, average lead time and capacity utilization provide an overall view of the transportation process. Since the ETL update is done once a day (during the morning) and the data provided by Shipping Company Y concern the previous day, these visualizations also show information concerning the previous day.

Other visualizations, such as the pie chart containing the distribution of shipments between routes also provide further understanding of transportation. According to the graph, more than 95% of online sales were delivered within Portugal's continental territory, while Madeira and Azores represented less than 4% of shipments.

The volume of shipments per shipping company against capacity also contributes to contextualize the user. As seen in the provided chart, transportation operates far from its capacity limit, with a rare exception on week 2. So, rethinking its strategy may help reduce costs and eliminate waste. Shipping Company Y's and Shipping Company Z's individual capacities are shown in the tooltip.

The other charts presented have a deeper focus on transportation's everyday operation. Through shipment statuses, team members are able to visualize the progress of shipments overtime, from the moment they were picked up until the moment they were delivered. It also allows them to identify backlogs and possible deviations.

The stacked bar chart containing the weighted volume of shipments that achieved the lead time goal allows users to visualize deviations as well. This is one of Company X's most required supply chain analyses and provides an overall assessment of the process performance. Each group (Systems, Operation and Transportation) considers its own levels of success, designed to fit each of their lead time goals.

For Transportation, this calculation is based on the comparison of two dates: delivery date and expected delivery date. To calculate the second one, it is necessary to consider the day of the week, upcoming holidays and location of final delivery (if it is in Madeira, Azores or continental Portugal). Then, by comparing both dates, one of five levels of success may be obtained: D, D+1, D+2, D+3 or D+n. If a shipment is delivered before or on the expected delivery date, it is assigned the level D. If it is delivered one day after the expected delivery date, it is said to be D+1, and so on.

To help identify possible causes of deviation and allow Transportation teams to improve their process, a table is provided containing occurrences that impose a delay on delivery and their frequencies for the past year. At the moment, however, this information is provided only for Shipping Company Y.

In order to complete this dashboard, appropriate filters were chosen. It is important to remember that Transportation comprehends the process between the moment the shipment is picked up from the warehouse or from the supplier store and the moment of its final delivery. So, if a unit within the shipment is a pre-order or a longtail, Transportation's performance will not be affected. On the other hand, different routes may have different delivery criteria, which makes it an appropriate filter. It is also interesting to visualize the data according to the preparation location, shipping company and delivery site. So, the final filter considered was "Flow".

4.4.2. Online Sales Supply Chain E2E Process Summary

The second dashboard built was focused on the online sales E2E process and it is presented on Figure 4.4 of the previous chapter. Unlike the previous dashboard, this one should have a tactical/strategic focus. It is primarily consumed on a weekly meeting between supply chain executives and warehouse operation managers.

Since this dashboard comprehends the E2E process, it is appropriate to consider every sold unit from the moment of payment until the moment of delivery.

On the top left corner of the dashboard, a YTD summary of the entire process is presented. Through a gauge visualization, an overall rate of success is shown. It is possible to observe that, unlike the objective set (which was of 0,90), the process presented a rate of success of 0,47 for the current year. A card visualization also shows a use of only half of the process capacity, which shows that there is room for improvement. Other two card visualizations present the YTD volume produced and the average process lead time.

Due to recently established business strategies, product category became an important point of analysis. In order to satisfy that necessity, a clustered column chart was used to compare sales volumes of the top ten categories for the current and past year. A dashboard filter containing all product categories was also employed to allow the manipulation of other charts.

Another concern presented by supply chain executives concerns the distribution of online sales preparation between warehouse and supplier stores. It is of interest to reduce distances (preparation from delivery) and to increase the number of orders that fit into the "SS-SS" flow option (order is prepared in the same store chosen as the delivery site). For this analysis to be a possibility, a pie chart was used as well as a "Flow" dashboard filter.

As previously stated for the Transportation dashboard, Company X strongly relies on the analysis of the weighted volume of shipments that achieved the lead time goal to assess the process performance. For that purpose, two stacked column charts were used. The first one considers the last seven days while the other considers the past weeks.

Different purchase order units are distributed between five levels of success: D+1, D+2, D+3, D+4 and D+n. It is important to mention that, for continental Portugal deliveries, a purchase order is expected to be delivered on the next business day of its payment. So, to calculate the appropriate level, the following factors are considered: day of the week of the payment, cutoff hour of 8 PM, holidays and route. If a unit has a calculated level of D+1 it means that it achieved the objected and was delivered on the next business day of its payment. On the other hand, if it is delivered one day after the next business day, a level of D+2 is assigned, and so on.

To complete this analysis, the volume of orders fulfilled is presented on absolute and relative terms for the past seven days.

Finally, three other filters were provided due to their impact on the analysis. These are: Route, Longtail and Pre-Order.

4.4.3. Online Sales Supply Chain E2E Process Summary (Campaign Season)

The third dashboard built was also focused on the online sales E2E process, but this time concerning campaign seasons. It is presented on Figure 4.5 of the previous chapter. Since its main objective is to guide supply chain executives and warehouse operations managers through campaign seasons (such as Black Friday), it is important for it to contain information on an operational level.

Its structure is similar to the previous dashboard, with the difference that it only analyzes the orders impacted by the campaign. For example, visualizations on the top left corner keep track only of orders made during the campaign period. On the other hand, visualizations that give information about the last 7 days may present orders that were created before the campaign, since they will still have an impact on the preparation and transportation process. The dashboard also provides an hour to hour analysis of the distribution of purchase order units between statuses. Through the continuous observation of their progress, operations managers can identify deviations and take immediate action.

4.4.4. Systems, Operation and Transportation Performance Assessment

The final dashboard comes to fulfill the necessity of further information concerning specific groups (Systems, Operation and Transportation) since the lack of data prevented from the development of two of the proposed dashboards. It is shown on Figure 4.6 of the previous chapter.

The dashboard structure allows for its intuitive reading and interpretation. It is divided into five sections. On the top left corner, an E2E process summary containing rate of success, volume produced, capacity utilization and average lead time, for the last 7 days, is observed. A chart of the distribution of orders between lead time levels of achievement is also observed. The top right corner, on the other hand, shows different dashboard filters. They were chosen following the same logic as the previous dashboards.

The last three sections present a performance assessment in the perspective of Systems, Operation and Transportation, respectively. For each one of them is presented a stacked column chart of their weighted volume of units/shipments that achieved the lead time goal in the last seven days. So, if any deviations are observed in the E2E process visualizations, it is possible to determine from each of groups it resulted from.

As it was already mentioned, the group Systems comprehends the process between the moment of payment and the moment of integration. It is expected of it to ensure that the elapsed time between those two moments is less or equal to 20 minutes. So, if a certain purchase order unit integrates in the system within those 20 minutes, it is assigned a D success level. If the elapsed time is greater than 20 minutes but less than 40 minutes, it is assigned a D+20 success level, and so on. The five possible levels are: D, D+20, D+40, D+60 and D+n.

Operation, on the other hand, comprehends the process between integration and expedition. From Monday through Friday, purchase order units that integrate until 8 PM are expected to be dispatched on the same day. From 8 PM on Friday through 8 PM on Saturday, purchase order units are expected to be dispatched on Sunday. For those that integrate from 8 PM on Saturday until 8 PM on Monday, expedition is expected to occur on Monday. Given these conditions, the five possible levels of success are: D, D+1, D+2, D+3 and D+n. If the expedition occurs on the expected date, it is assigned a level D. If it is dispatched one day after the expected date, it is assigned a level D+1, and so on.

The different levels of success for Transportation were already discussed in the first dashboard.

5. RESULTS AND DISCUSSION

This chapter consists of the "Evaluation" part proposed in the DSR methodology.

The developed BI solution and its outputs were analyzed against the previously defined objectives to conclude if these were met or not. As outputs, both data mart and dashboards were considered.

5.1. Discussion and Evaluation of the Results

This project started with the identification of a problem within Company X. In order to achieve the best solution, a series of objectives were first identified and a methodology was chosen. It was then followed by a thorough research which meant to identify best practices and previous works in literature that dealt with similar problems.

All the knowledge obtained, complemented by the identification of the business needs, led to the development of a conceptual model that addressed the proposed problem. The developed model extrapolated Company X's scenario and actually composed a solution for other companies facing similar challenges, which constituted one of the main objectives listed.

It is important to observe that the data mart fact tables proposed structure was not the most traditional. Due to one of the model's main requirements, they were better represented as a combination of accumulating snapshot and periodic snapshot fact tables. Even though this implicated in a more complex implementation process, the resulting data mart model answered to all business requirements and provided an appropriate solution for the problem. More specifically, the data mart provided fact tables on a unit level that allowed for each of these units to be tracked from the moment of their creation until the moment of their delivery. Besides that, all required information was presented and every milestone was registered through a timestamp.

For the implementation stage of the project, the definition of the software was first required. The chosen software can be said to have been appropriate for the problem, however there were some challenges during the ETL implementation. The computer provided, at the time, by Company X had significant memory problems and did not have the processing capabilities needed for the solution. Also, connections to operational systems provided by Company X were very unstable. Hence, the implemented solution required some adaptations so that it could be delivered in a timely manner.

Even though the ETL process faced some challenges, the final solution still presented improvements for Company X. It helped identify all data sources and concentrate all required extractions and transformations in the same place. It also provided a central data repository (structured according to the identified business needs), as well as a solution for the changes that resulted from the replacement of the former warehouse management system.

The implementation of the dashboards also faced some challenges. Due to the lack of data, not all proposed dashboards were viable and some alterations had to be made. Even with some restrictions, supply chain groups were still able to assess their performances on an operational level. Also, analysis on extended periods of time and on different perspectives were provided. Finally, considering the needs listed for campaign seasons, users were able to visualize the progress between statuses of purchase order units overtime.

It is possible to say that the dashboards, both proposed and implemented, allow for an intuitive reading and interpretation. They are also interactive, and all visualizations and filters provided contribute to the fulfillment of the business requirements.

It is important to mention that it is made sure that all target users fully understand the information displayed in the dashboards. Also, all observations and evaluation concerning the artifact developed in this project reflect the comments and feedback given by each of the users.

A final evaluation, which ranged from 0 to 10, was made in order to identify the project's level of achievement. The topics evaluated were: 1) Extraction of data directly from the data source; 2) Eliminates manual tasks; 3) Artifact may be implemented in other companies facing similar challenges; 4) Dimensions, fact tables and granularity chosen are appropriate; 5) Solution is user friendly; 6) Allows faster reporting; 7) Provides more accurate reporting; 8) Data centered in a single data repository. All topics scored between 8 and 10, with an average of 8,9. Results can be seen in Figure 6.1 in the next chapter.

6. CONCLUSION

The current project presented as its main goal the development of a conceptual model of a BI system that served as a solution to the needs of an online sales supply chain E2E operation. It was required that this solution would not focus on a specific company. Instead, it should provide a solution for all companies facing similar problems.

Only after the development of a conceptual model the artifact would be developed. Up until the start of this project, Company X's supply chain BI team had to deal with a previously developed solution that was not properly structured. It involved the use of multiple Microsoft Access and Excel files, which limited its performance. In addition, a change in the warehouse management system resulted in an urgent need of a solution. These circumstances combined provided the company with the challenge and opportunity to improve their current solution. Given all of these reasons, Company X constituted an appropriate candidate for this case study.

The project was structured according to the DSR methodology from which all stages were completed. In order to reach the best solution for the problem, a thorough research in the literature was conducted. As outputs of the project are considered both data mart and dashboards.

From the work presented, it is possible to conclude that the final solution meets all the defined objectives. All listed requirements are taken into account as well as best practices mentioned in the literature.

Many challenges were faced throughout the project, specially during implementation. A not so traditional data mart model resulted in a more complex ETL process. Also, since not all required data was provided, it was not possible to go through with the dashboard models exactly as they were. What had been proposed in the conceptual model is still considered to be ideal. It was developed as a solution for a certain type of problem and was not focused on a specific company. So, it is not expected for it to fit perfectly into a certain company's scenario. However, even with some imposed changes, all business requirements were met and Company X still got the necessary improvements.

A final evaluation was developed in order to identify the project's level of achievement.

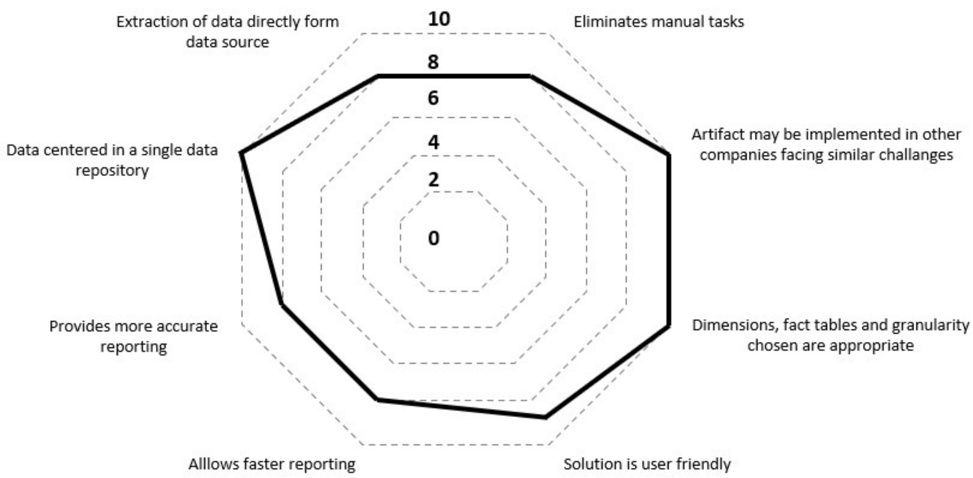


Figure 6.1 – Evaluation of the artifact

This evaluation is mainly focused on the identified recommendations from works in the literature, on the listed project objectives and on its main motivations.

Even with some challenges, it is possible to say that the project reached a successful result. The conceptual model developed provided a solution not only to Company X, but to all companies with similar needs. Also, with this well-structured BI solution, Company X is now able to share quality information along its supply chain, reporting became more accurate and faster, and BI team members time was optimized. This all results in a consequent improvement of the decision-making process.

Also concerning the visualization part of the project, the result was a group of intuitive and wellstructured dashboards. Each of the supply chain individual teams are able to assess their performance, visualize deviations and act on the observed problems.

7. LIMITATIONS AND RECOMMENDATIONS FOR FUTURE WORKS

The limitations observed during the development of the project are the following:

- The computer provided by Company X had significant memory problems and did not have the processing capabilities needed for the solution;
- Connections to operational systems provided by Company X were very unstable and resulted in longer package deployment times;
- Data from different data sources had different formats and nomenclature, which contributed to a more complex ETL process;
- The need to track each purchase order unit throughout the entire E2E process made the development of an appropriate data mart model much more complex, as well as the ETL process;
- Since some of the required data was not provided by Company X, limitations were imposed on the implementation of the dashboards;
- The change of the warehouse management system resulted in the urgent need to develop a solution;
- Not all required data is integrated in the operational systems. So, it is still necessary to manipulate manually those data sources composed by excel files that are provided daily/weekly.

Bellow, are presented the recommendations for future works:

- Performance indicators determined by the weighted volume of units/shipments that achieved the lead time goal were based on previously existing practices of Company X. The way they are formulated does not allow the visualization of the impact of orders that still have not gone through the complete process. An improvement would be to include an additional level of success, so that the impact of pending orders can be observed;
- Even though purchase order units'/shipments' volumes are measures of interest, it would be more informative to have those values relative to the number of worked hours. So, for future developments, it would be of interest to have the necessary data (needed to obtain that calculation) integrated to the system;
- Understanding the reasons why orders do not achieve the highest levels of success is just as important as assessing processes performances. So, for future developments, access to occurrences data is suggested. At the moment, this is only provided for Shipping Company Y;
- It would be of interest to integrate in the existing solution data that describes the stages that orders go through in the preparation process (not yet provided by the company);
- It is suggested to explore different tools in order to improve the ETL process;

- Conduct a survey to obtain users' opinions regarding the current solution and to define which of its aspects can be improved;

- For future works, it would be interesting to have a table on the dashboards, or even a separate report, with the detail of online orders that presented delays during the process;

- Finally, it is suggested to build a structure to store meta data, which was not yet possible.

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9. APPENDIX

DimDate	Description
SK_Date	Surrogate key.
PK_FullDate	Date containing year-month-day.
DayNumberOfMonth	Number of the day of the month.
DayNameOfWeek	Name of the day of the week. Ex.: Monday and Tuesday.
DayNumberOfWeek[3]	Number of the day of the week.
WeekNumberOfYear	Number of the week in the year.
MonthNumberOfYear	Number of the month in the year.
MonthNameOfYear	Name of the month of the year. Ex.: January and June.
QuarterNumberOfYear	Number of the quarter of the year.
SemesterNumberOfYear	Number of the semester of the year.
Year	Year that corresponds to the date (number).
Is_Holiday	Flag that identifies if the date is a holiday.
Is_Weekday	Flag that identifies if the date is a weekday.
SeasonNameOfYear	Name of the current season. Ex.: Summer, Spring, Fall, Winter.

Table 9.1 – DimDate fields and their respective descriptions

DimProduct	Description
SK_Product	Surrogate key.
ProductSKU	Stock Keeping Unit; identifies a distinct type of item.
ProductName	Complete name of the product.
ProductSubClassNo	Number that identifies the subclass of the product.
ProductSubClassName	Name of the subclass.

[3] It is necessary to be clear if, in the company, it is more appropriate to consider the week to start on Sunday or on Monday.

ProductClassNo	Number that identifies the class of the product.
ProductClassName	Name of the class.
ProductDepartmentNo	Number that identifies the department of the product.
ProductDepartmentName	Name of the department.
ProductGroupNo	Number that identifies the group of the product.
ProductGroupName	Name of the group.
ProductStatus	Status that identifies if the product is active or not (available or not for sale).
ProductSupplierNo	Number that identifies the supplier.
ProductSupplierName	Name of the supplier.
ProductDimensions	Represents the size of the product. Ex: 30cm x 10cm x 20cm.
ProductDimensionRange	Identifies if the product is a small, medium or large format.
ProductColor	Color of the product.
ProductStandardCost	Estimated cost of the product (to obtain from the supplier or to manufacture it).
ProductListPrice	Suggested retail price.
ProductSCDStartDate	Moment when the record became active.
ProductSCDEndDate	Moment when the record became inactive.

Table 9.2 – DimProduct fields and their respective descriptions

DimAddress	Description
SK_Address	Surrogate key.
AddressType	Code that identifies if the address is a warehouse, a store or a customer address.
AddressTypeDesc	Description of the address type.
AddressPostalCode	Postal code of the location.
AddressNeighborhood	Neighborhood of the location.

AddressCity	City of the location.
AddressCountry	Country of the location.
AddressStateOrProvince	State or province within the country of the location.

Table 9.3 – DimAddress fields and their respective descriptions

DimFlow	Description
SK_Flow	Surrogate key.
FlowType	Abbreviation that represents the flow type.
FlowDesc	Description of the flow; from where the purchase was prepared to where it was delivered.
FlowStatus	Identifies if the flow is active or inactive.
FlowSCDStartDate	Moment when the record became active.
FlowSCDEndDate	Moment when the record became inactive.

Table 9.4 – DimFlow fields and their respective descriptions

DimShipCompany	Description
SK_ShipCompany	Surrogate key.
ShipCompanyName	Name of the shipping company.
ShipCompanyAddress	Address of the shipping company headquarters.
ShipCompanyCity	City of the shipping company headquarters.
ShipCompanyPhone	Phone contact of the shipping company.
ShipCompanyEmail	Email contact of the shipping company.
ShipCompanyPickupFrequency	Frequency the shipping company picks up orders on the agreed location.
ShipCompanyStatus	Identifies if the shipping company is still being employed by the company (active or not).
ShipCompanySCDStartDate	Moment when the record became active.
ShipComapnySCDEndDate	Moment when the record became inactive.

Table 9.5 – DimShipCompany fields and their respective descriptions

DimStore	Description
SK_Store	Surrogate key.
StoreName	Name/identification of the store.
StoreAddress	Address where the store is located.
StoreCity	City where the store is located.
StorePhone	Phone contact of the store.
StoreCategory	Classification of the store / store type (specific to each business).
StoreNoOfEmployees	Number of employees that work in the store.
StoreStatus	Identifies if the store is still operating or not (active or not).
StoreSCDStartDate	Moment when the record became active.
StoreSCDEndDate	Moment when the record became inactive.

Table 9.6 – DimStore fields and their respective descriptions

DimStatus	Description
SK_Status	Surrogate key.
StatusProcess	Identifies if the status belongs to the overall E2E process, Systems, Operation or Transportation.
StatusName	Name defined for the specific status.
StatusDescription	Description of the status.

Table 9.7 – DimStatus fields and their respective descriptions

FactOnlineSalesE2E	Description

OrderUnitKey	Combination of the purchase order unit number and the record repetition number; composes the primary key of the fact table.
FK_CreateDate	Foreign key that identifies the creation date of the purchase order; composes the primary key of the fact table; field joined to DimDate.
PaymentDateKey	Identifies the payment date of the purchase order; field joined to DimDate.
IntegrationDateKey	Identifies the integration date of the purchase order; field joined to DimDate.
ExpeditionDateKey	Identifies the expedition date of the purchase order; field joined to DimDate.
PickupDateKey	Identifies the pickup date of the purchase order; field joined to DimDate.
DeliveryDateKey	Identifies the delivery date of the purchase order; field joined to DimDate.
FK_Product	Foreign key that identifies the product that the unit from the purchase order corresponds to; field joined to DimProduct.
PrepAddressKey	Address of the site where that unit from the purchase order was prepared before being shipped to the customer; field joined to DimAddress.
DeliveryAddressKey	Address of the site chosen by the customer where the purchase order should be delivered at; field joined to DimAddress.
FlowKey	Identifies the flow through which the unit from the purchase order goes (Ex.: Preparation site – Shipping Company – Delivery site); field joined to DimFlow.
StatusKey	Identifies the current status of the unit in the purchase order in the E2E process; field joined to DimStatus.
ShipCompanyKey	Identifies the shipping company chosen to deliver the unit; field joined to DimShipCompany.
StoreKey	Identifies the store where the online sale was made (through SA or by the customer directly in the website); field joined to DimStore.
OrderUnitNumber	ID that identifies the purchase order unit.
OrderNumber	ID that identifies the purchase order.
TrackingNumber	ID that identifies the shipment in which the unit was sent to be delivered to the customer.

CreateDate	Timestamp that identifies the moment in which the purchase order was created.
PaymentDate	Timestamp that identifies the moment in which the payment of the purchase order was completed.
IntegrationDate	Timestamp that identifies the moment in which the purchase order integrated in the appropriate system (it became available to be picked and packed).
ExpeditionDate	Timestamp that identifies the moment of expedition of the purchase order unit (it became available to be picked up by the shipping company for delivery).
PickupDate	Timestamp that identifies the moment in which the unit, within a shipment, was picked up by the shipping company to be delivered.
DeliveryDate	Timestamp that identifies the moment of delivery.
CancelMoment	Timestamp that identifies the moment the order was canceled.
ExpectedDeliveyDate	Timestamp that identifies the expected moment of delivery (according to what was promised to the customer).
PreOrderFlag	Flag that identifies if the purchase order unit represents a pre-order or not.
SuccessFlag	Flag that identifies if the delivery was done before the expected date or not.
MultiMonoFlag	Flag that identifies if the purchase order had multiple items or not.
LeadTime	Elapsed time from the moment the purchase order was payed until the moment the purchase order unit was delivered.
SnapshotStartDate	Moment when the record became active.
SnapshotEndDate	Moment when the record became inactive.

Table 9.8 – FactOnlineSalesE2E fields and their respective descriptions

FactSystems	**Description**
OrderUnitKey	Combination of the purchase order unit number and the record repetition number; composes the primary key of the fact table.
FK_CreateDate	Foreign key that identifies the creation date of the purchase order; composes the primary key of the fact table; field joined to DimDate.

PaymentDateKey	Identifies the payment date of the purchase order; field joined to DimDate.
IntegrationDateKey	Identifies the integration date of the purchase order; field joined to DimDate.
FK_Product	Foreign key that identifies the product that the unit from the purchase order corresponds to; field joined to DimProduct.
PrepAddressKey	Address of the site where that unit from the purchase order was prepared before being shipped to the customer; identifies the place (system) where the unit becomes available to be prepared after the moment of integration; field joined to DimAddress.
StatusKey	Identifies the current status of the unit in the process which is in the responsibility of Systems; field joined to DimStatus.
OrderUnitNumber	ID that identifies the purchase order unit.
OrderNumber	ID that identifies the purchase order.
CreateDate	Timestamp that identifies the moment in which the purchase order was created.
PaymentDate	Timestamp that identifies the moment in which the payment of the purchase order was completed.
IntegrationDate	Timestamp that identifies the moment in which the purchase order integrated in the appropriate system (it became available to be picked and packed).
ExpectedIntegrationDate	Timestamp that identifies the expected moment of integration (according to the objectives stablished by the company).
PreOrderFlag	Flag that identifies if the purchase order unit represents a pre-order or not.
SuccessFlag	Flag that identifies if the integration was accomplished before the expected date or not.
MultiMonoFlag	Flag that identifies if the purchase order had multiple items or not.
LeadTime	Elapsed time from the moment the purchase order was payed until the moment the purchase order unit integrated in the appropriate system.
SnapshotStartDate	Moment when the record became active.
SnapshotEndDate	Moment when the record became inactive.

Table 9.9 – FactSystems fields and their respective descriptions

FactOperation	Description
OrderUnitKey	Combination of the purchase order unit number and the record repetition number; composes the primary key of the fact table.
FK_CreateDate	Foreign key that identifies the creation date of the purchase order; composes the primary key of the fact table; field joined to DimDate.
IntegrationDateKey	Identifies the integration date of the purchase order; field joined to DimDate.
ExpeditionDateKey	Identifies the expedition date of the purchase order; field joined to DimDate.
FK_Product	Foreign key that identifies the product that the unit from the purchase order corresponds to; field joined to DimProduct.
PrepAddressKey	Address of the site where that unit from the purchase order was prepared before being shipped to the customer; field joined to DimAddress.
StatusKey	Identifies the current status of the unit in the process which is in the responsibility of Operation; field joined to DimStatus.
OrderUnitNumber	ID that identifies the purchase order unit.
OrderNumber	ID that identifies the purchase order.
CreateDate	Timestamp that identifies the moment in which the purchase order was created.
IntegrationDate	Timestamp that identifies the moment in which the purchase order integrated in the appropriate system (it became available to be picked and packed).
PickingDate	Timestamp that identifies the moment in which the unit was picked during the preparation process (this milestone of the process is only meant to exemplify possible milestones of the operation subprocess that can be presented in the fact table).
PackingDate	Timestamp that identifies the moment in which the unit was packed during the preparation process (this milestone of the process is only meant to exemplify possible milestones of the operation subprocess that can be presented in the fact table).
ExpeditionDate	Timestamp that identifies the moment of expedition of the purchase order unit (it became available to be picked up by the shipping company for delivery).

ExpectedExpeditionDate	Timestamp that identifies the expected moment of expedition (according to the objectives stablished by the company).
PreOrderFlag	Flag that identifies if the purchase order unit represents a pre-order or not.
SuccessFlag	Flag that identifies if the expedition was accomplished before the expected date or not.
MultiMonoFlag	Flag that identifies if the purchase order had multiple items or not.
LeadTime	Elapsed time from the moment of integration until the moment of expedition.
SnapshotStartDate	Moment when the record became active.
SnapshotEndDate	Moment when the record became inactive.

Table 9.10 – FactOperation fields and their respective descriptions

FactTransportation	Description
OrderUnitKey	Combination of the purchase order unit number and the record repetition number; composes the primary key of the fact table.
FK_CreateDate	Foreign key that identifies the creation date of the purchase order; composes the primary key of the fact table; field joined to DimDate.
PickupDateKey	Identifies the pickup date of the purchase order; field joined to DimDate.
DeliveryDateKey	Identifies the delivery date of the purchase order; field joined to DimDate.
FK_Product	Foreign key that identifies the product that the unit from the purchase order corresponds to; field joined to DimProduct.
PrepAddressKey	Address of the site where that unit from the purchase order was prepared before being shipped to the customer; pickup site; field joined to DimAddress.
DeliveryAddressKey	Address of the site chosen by the customer where the purchase order should be delivered at; field joined to DimAddress.
FlowKey	Identifies the flow through which the unit from the purchase order goes (Ex.: Preparation site – Shipping Company – Delivery site); field joined to DimFlow.
StatusKey	Identifies the current status of the unit in the process which is in the responsibility of Transportation; field joined to DimStatus.

ShipCompanyKey	Identifies the shipping company chosen to deliver the unit; field joined to DimShipCompany.
OrderUnitNumber	ID that identifies the purchase order unit.
OrderNumber	ID that identifies the purchase order.
TrackingNumber	ID that identifies the shipment in which the unit was sent to be delivered to the customer.
CreateDate	Timestamp that identifies the moment in which the purchase order was created.
PickupDate	Timestamp that identifies the moment in which the unit, within a shipment, was picked up by the shipping company to be delivered.
ShippingCenterEntranceDate	Timestamp that identifies the moment in which the unit, withing a shipment, entered the shipping company's package processing center (this milestone of the process is only meant to exemplify possible
	milestones of the transportation subprocess that can be presented in the fact table).
OutForDeliveryDate	Timestamp that identifies the moment in which the unit, withing a shipment, left the shipping company's package processing center for delivery (this milestone of the process is only meant to exemplify possible milestones of the transportation subprocess that can be presented in the fact table).
DeliveryDate	Timestamp that identifies the moment of delivery.
ExpectedDeliveryDate	Timestamp that identifies the expected moment of delivery (according to the objectives stablished by the company).
PreOrderFlag	Flag that identifies if the purchase order unit represents a pre-order or not.
SuccessFlag	Flag that identifies if the delivery was accomplished before the expected date or not.
MultiMonoFlag	Flag that identifies if the purchase order had multiple items or not.
LeadTime	Elapsed time from the moment of pickup until the moment of delivery.
SnapshotStartDate	Moment when the record became active.
SnapshotEndDate	Moment when the record became inactive.

Table 9.11 – FactTransportation fields and their respective description

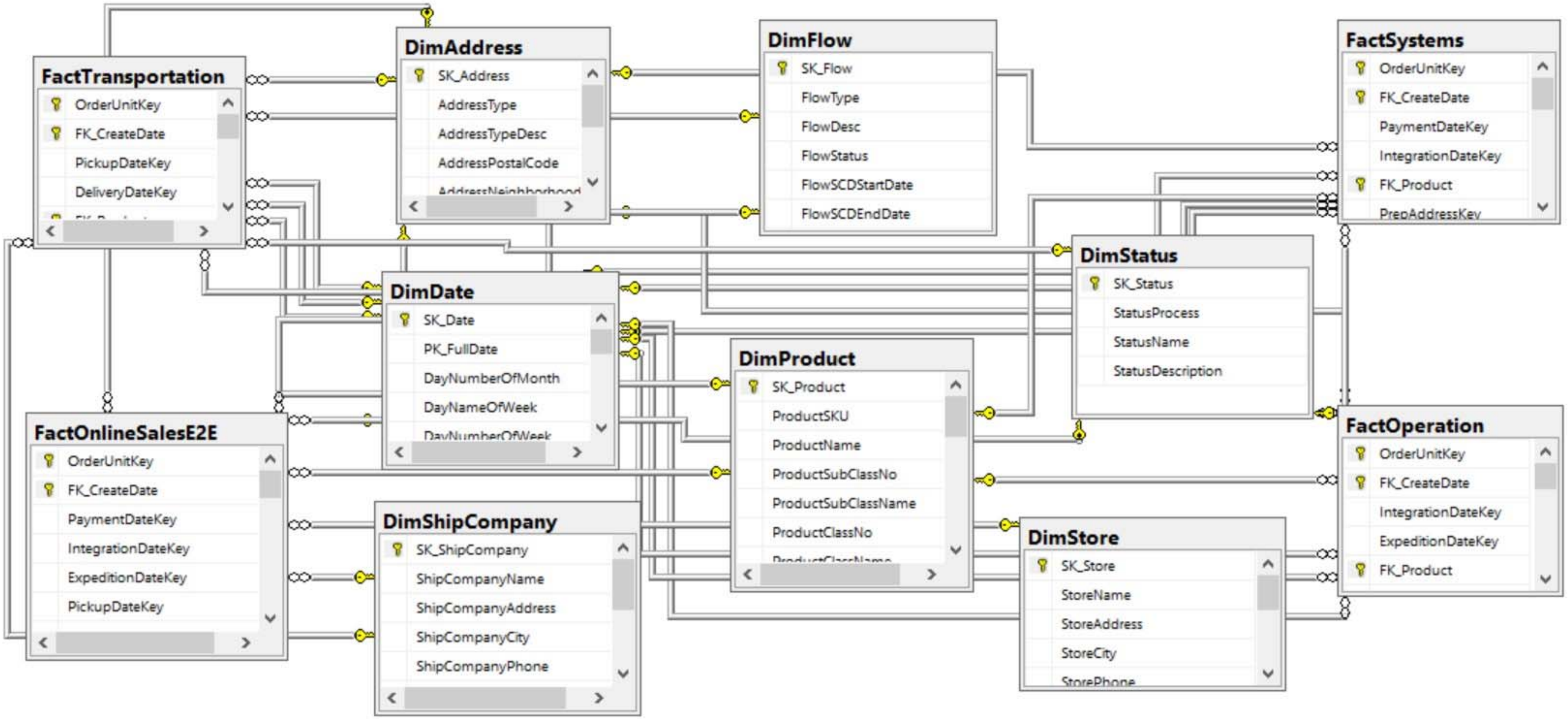

Figure 9.1 – Diagram of the conceptual data mart model

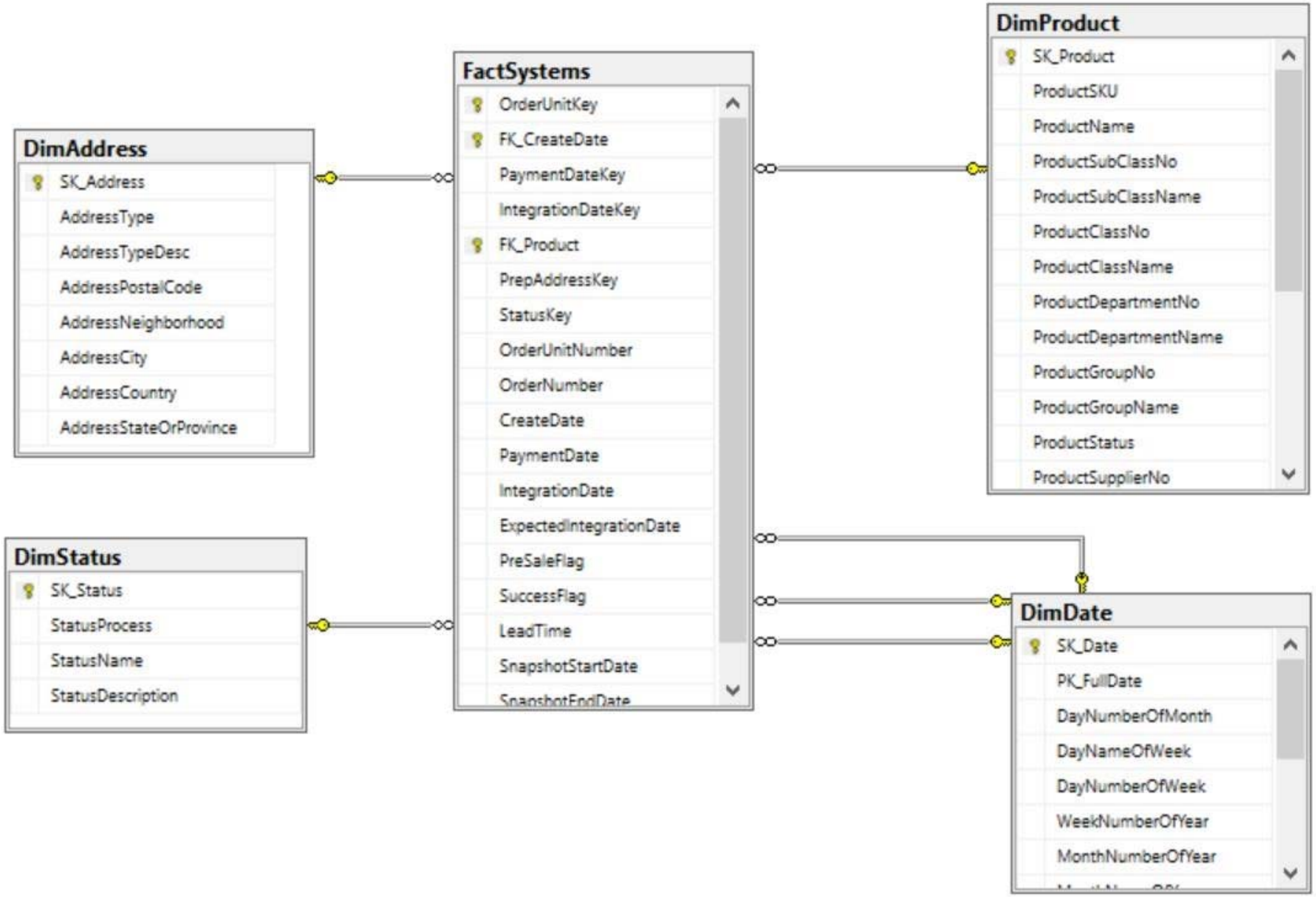

Figure 9.2– Zoom of the diagram of the data mart model focusing solely on FactSystems and its dimensions

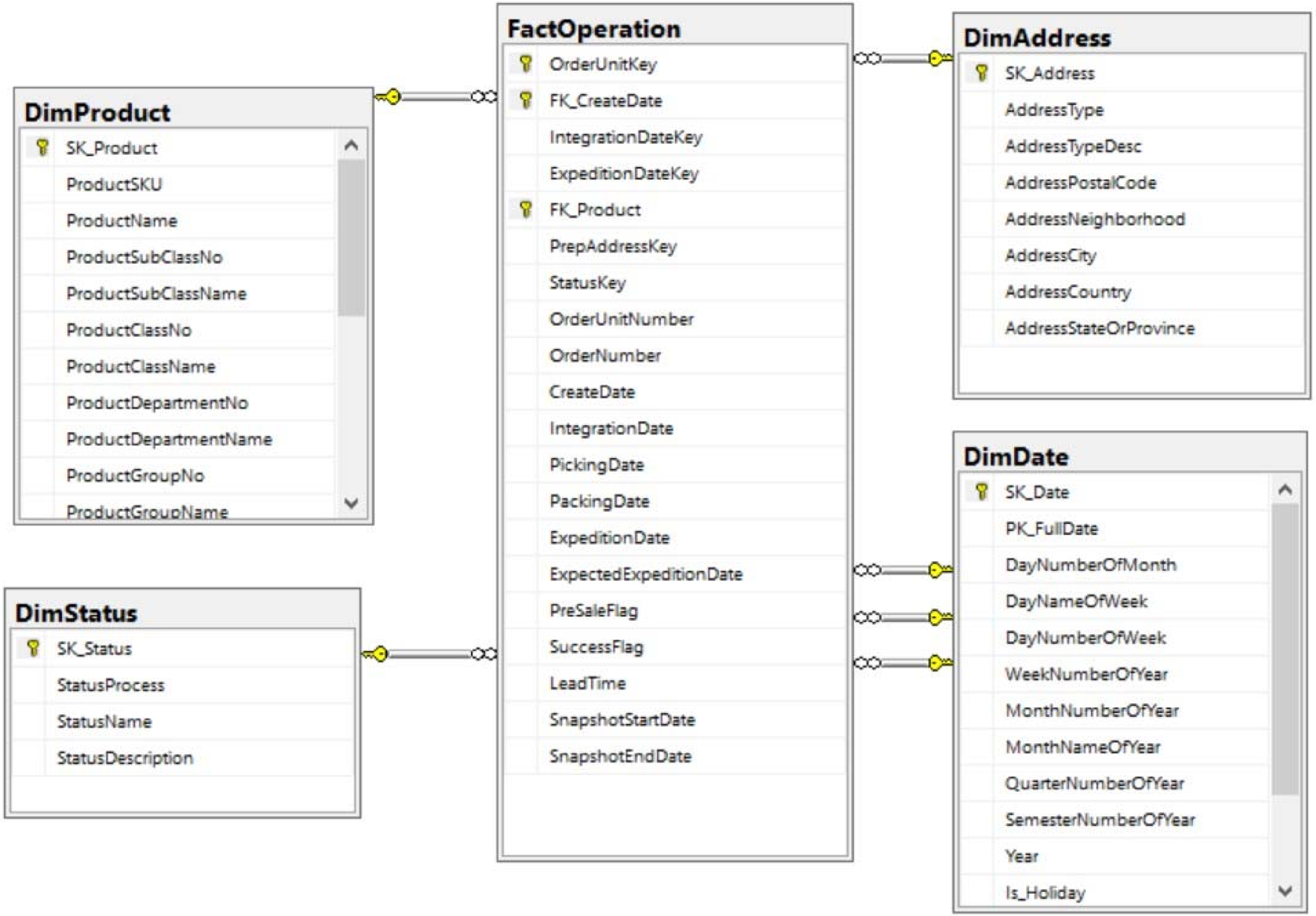

Figure 9.3 – Zoom of the diagram of the data mart model focusing solely on FactOperation and its dimensions

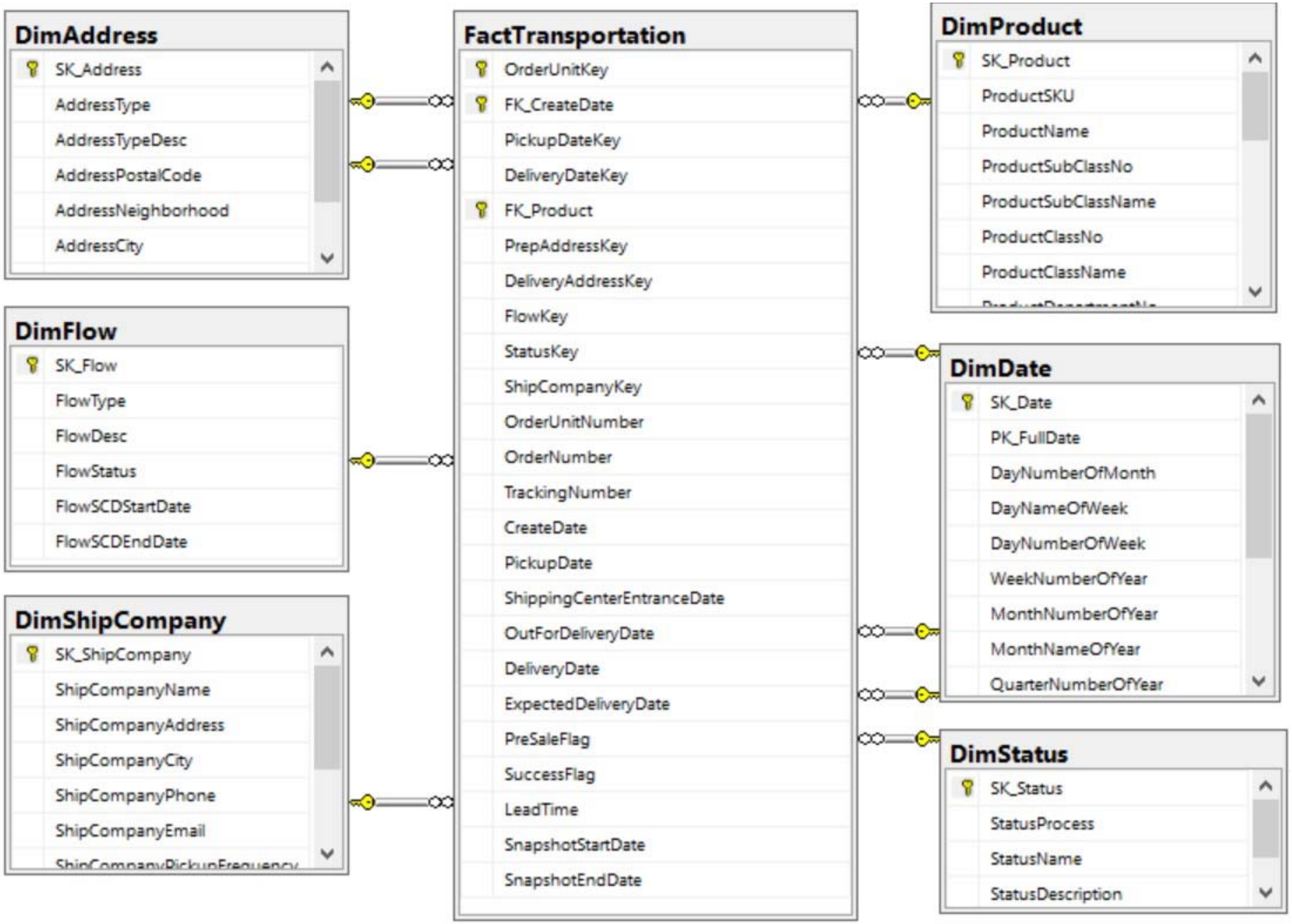

Figure 9.4 – Zoom of the diagram of the data mart model focusing solely on FactTransportation and its dimensions

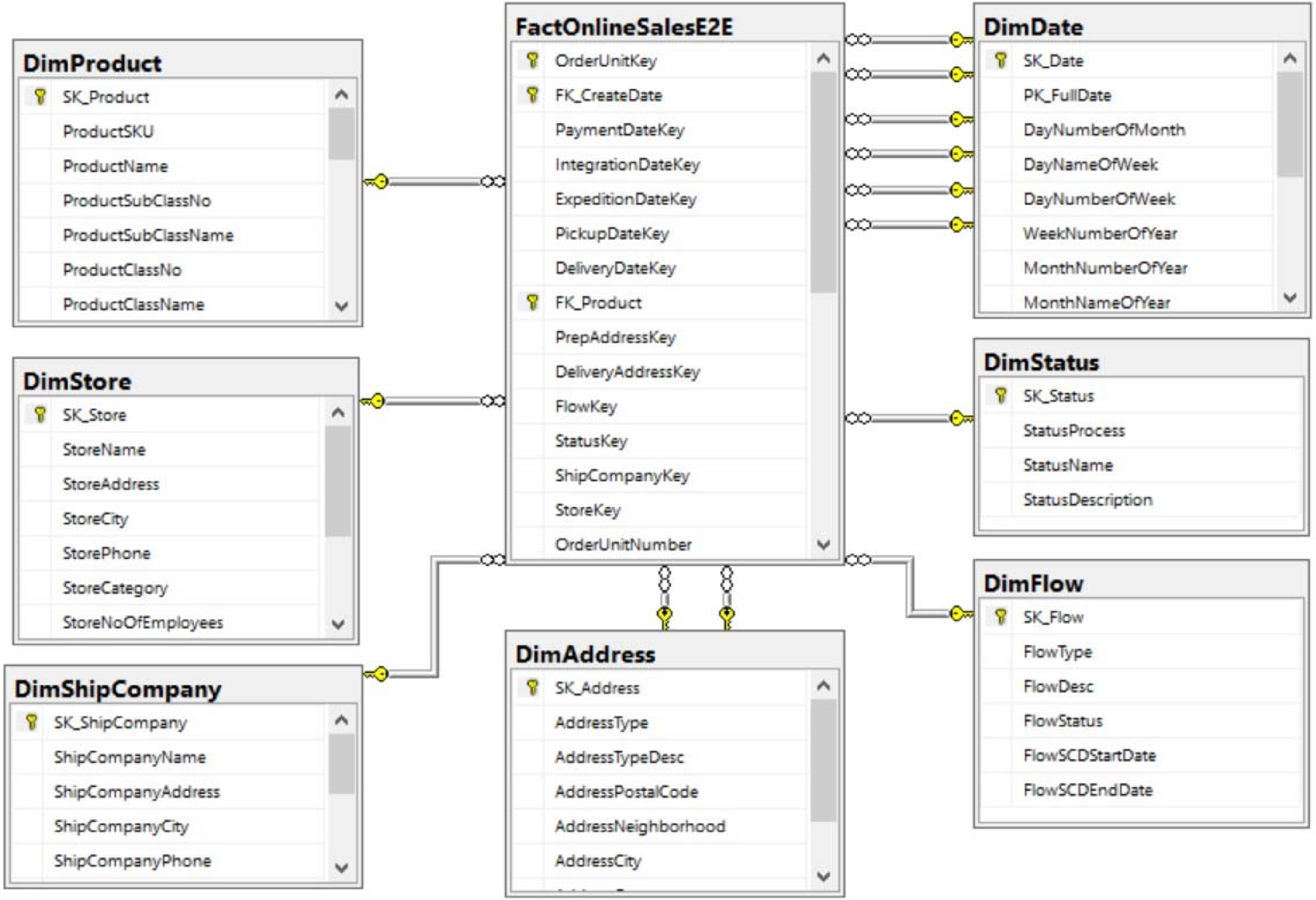

Figure 9.5 – Zoom of the diagram of the data mart model focusing solely on FactOnlineSalesE2E and its dimension

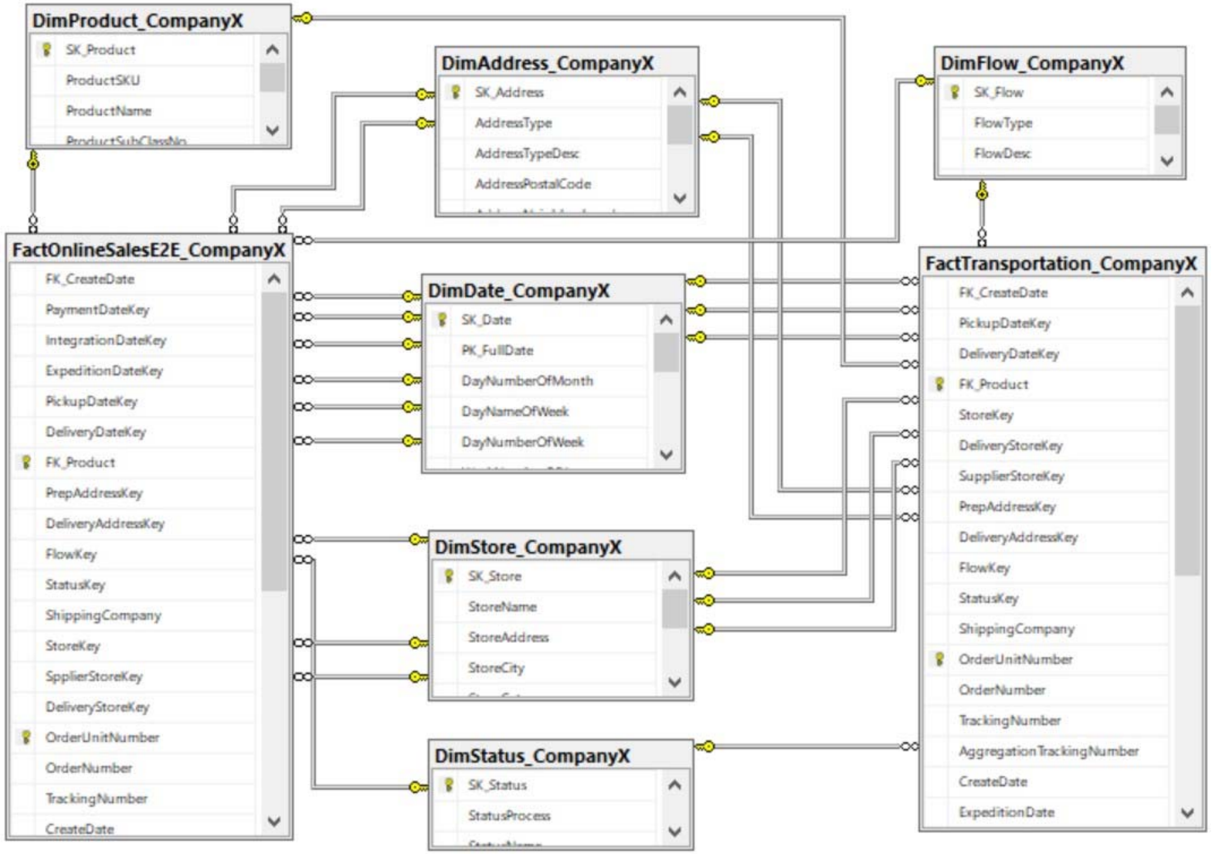

Figure 9.6 – Diagram of Company X’s data mart.

Tables	Fields
Orders	Order_ID
	Store_ID
	Order_No
	PIS_Store
	Create_Date
	Unlock_Moment
	Cancel_Moment
Orders_Item	Product_ID
	Product_Full_Name
	Product_Desc
	Qty_Requested
	Qty_Picked
	Qty_Shipped
	Qty_Delivered
	Orders_Item_Status_ID
Shipping_List	Operator_Tracking_No
	Shipping_List_ID
	Shipping_List_No
	Preparation_Store
	Shipping_List_Status_ID
	Shipping_SCED_Flag
	Is_Mono_Product_Flag
Shipping_List_Item	Order_Item_ID

	Shipping_Item_Status_ID
Shipping_Manifest	First_Tracking_No
	Last_Tracking_No
Shipping_State_History	Shipping_Last_Status_ID
	Last_Status_Desc
	Modified_Date
Address	Postal_Code
	City
Address_Type	Address_Type_ID

Table 9.12 – OMS used tables and respective fields

Tables	Fields
Orders	Reference_Field
	Distribution_Order
	Integration_Date
	Order_Type
	Delivery_Type
	Store_ID
Orders_Item	SKU
	Qty_Ordered
	Shipping_Date
Orders_Item_Attribute	Order_Item_ID
LPN	oLPN
	Tracking_No
	Return_Tracking_No

	Flow
	OMS_Status
LPN_Status	oLPN_Status
LPN_Detail	Qty_LPN_Line
LPN_Output	Aggregation_Tracking_No
System_Code	Distribution_Order_Status
	Distribution_Order_Item_Status

Table 9.13 – WMS used tables and respective fields

Tables	**Fields**
Sales_Order_Head	Store
	Channel
	Channel_Order_No
	Payment_Indicator
	Create_Date
	Status
	Origin
Product_Desc	SKU
	Product_Name
	Department_No
	Class_No
	Sub_Class_No
Sub_Class	Sub_Class_Name
Class	Class_Name
Department	Department_Name

Groups	Group_No
	Group_Name
Product_Status_WH	Product_Status
	Product_Supplier_No
Suppliers	Supplier_Name

Table 9.14 – RMOS used tables and respective fields

DimDate Fields	Data Source	Data Type
SK_Date	___	int
PK_FullDate	___	date
DayNumberOfMonth	___	int
DayNameOfWeek	___	nvarchar(50)
DayNumberOfWeek	___	int
WeekNumberOfYear	___	int
MonthNumberOfYear	___	int
MonthNameOfYear	___	nvarchar(50)
QuarterNumberOfYear	___	int
SemesterNumberOfYear	___	int
Year	___	int
Is_Holiday	___	bit
Is_Weekday	___	bit
SeasonNameOfYear	___	nvarchar(50)

Table 9.15 – Company X’s DimDate fields, data sources and data types

DimProduct Fields	Data Source	Data Type
SK_Product	___	int

ProductSKU	RMOS.Product_Desc	nvarchar(50)
ProductName	RMOS.Product_Desc	nvarchar(MAX)
ProductSubClassNo	RMOS.Product_Desc	int
ProductSubClassName	RMOS.Sub_Class	nvarchar(50)
ProductClassNo	RMOS.Product_Desc	int
ProductClassName	RMOS.Class	nvarchar(50)
ProductDepartmentNo	RMOS.Product_Desc	int
ProductDepartmentName	RMOS.Department	nvarchar(50)
ProductGroupNo	RMOS.Goups	int
ProductGroupName	RMOS.Goups	nvarchar(50)
ProductStatus	RMOS.Product_Status_WH	nvarchar(50)
ProductSupplierNo	nvarchar(50)	int
ProductSupplierName	RMOS.Suppliers	nvarchar(50)
ProductSCDStartDate	___	datetime
ProductSCDEndDate	___	datetime

Table 9.16 – Company X's DimProduct fields, data sources and data types

DimAddress Fields	Data Source	Data Type
SK_Address	___	int
AddressType	OMS.Address_Type	int
AddressTypeDesc	OMS.Address_Type	nvarchar(50)
AddressPostalCode	OMS.Address	nvarchar(50)
AddressNeighborhood	OMS.Address	nvarchar(50)
AddressCity	OMS.Address	nvarchar(50)
AddressCountry	OMS.Address	nvarchar(50)

AddressStateOrProvince	OMS.Address	nvarchar(50)

Table 9.17 – Company X’s DimAddress fields, data sources and data types

DimFlow Fields	Data Source	Data Type
SK_Flow	___	int
FlowType	___	nvarchar(50)
FlowDesc	___	nvarchar(MAX)
FlowStatus	___	nvarchar(50)
FlowSCDStartDate	___	datetime
FlowSCDEndDate	___	datetime

Table 9.18 – Company X’s DimFlow fields, data sources and data types

DimStore Fields	Data Source	Data Type
SK_Store	RMOS.Store	int
StoreName	RMOS.Store	nvarchar(50)
StoreAddress	RMOS.Store	nvarchar(MAX)
StoreCity	RMOS.Store	nvarchar(50)
StoreCategory	___	nvarchar(50)
StoreStatus	RMOS.Store	nvarchar(50)

StoreSCDStartDate	___	datetime
StoreSCDEndDate	___	datetime

Table 9.19 – Company X’s DimStore fields, data sources and data types

DimStatus Fields	Data Source	Data Type
SK_Status	___	int
StatusProcess	___	nvarchar(50)
StatusName	___	nvarchar(50)
StatusDescription	___	nvarchar(MAX)

Table 9.20 – Company X’s DimStatus fields, data sources and data types

FactOnlineSalesE2E Fields	Data Source	Data Type
FK_CreateDate	OMS.Orders	int
PaymentDateKey	OMS.Orders; RMOS.Sales_Order_Head	int
IntegrationDateKey	OMS.Orders; WMS.Orders	int
ExpeditionDateKey	OMS.Shipping_State_History; WMS.Orders_Item	int
PickupDateKey	WMS.Orders_Item; Shipping Company Y Excel File	int
DeliveryDateKey	WMS.Orders_Item; Shipping Company Y Excel File	int
FK_Product	RMOS.Product_Desc	int
PrepAddressKey	OMS.Shipping_List	int
DeliveryAddressKey	OMS.Address	int
FlowKey	OMS.Orders	int
StatusKey	OMS.Shipping_List	int
ShippingCompany	OMS.Orders	nvarchar(50)
StoreKey	RMOS.SalesOrderHead	int
SupplierStoreKey	OMS.ShippingList	int

DeliveryStoreKey	OMS.Orders	int
OrderUnitNumber	OMS.Orders	nvarchar(50)
OrderNumber	OMS.Orders	nvarchar(50)
TrackingNumber	OMS.ShippingManifest; WMS.LPN	nvarchar(50)
CreateDate	OMS.Orders	datetime
PaymentDate	OMS.Orders; RMOS.Sales_Order_Head	datetime
IntegrationDate	OMS.Orders; WMS.Orders	datetime
ExpeditionDate	OMS.Shipping_State_History; WMS.Orders_Item	datetime
PickupDate	WMS.Orders_Item; Shipping Company Y	datetime
	Excel File	
DeliveryDate	WMS.Orders_Item; Shipping Company Y Excel File	datetime
CancelMoment	OMS.Orders	datetime
ExpectedDeliveryDate	WMS.Orders_Item; Shipping Company Y Excel File	datetime
PreOrderFlag	OMS.Orders_Item	bit
LongtailFlag	Longtail Excel File	bit
SuccessFlag	WMS.Orders_Item; Shipping Company Y Excel File	bit
MultiMonoFlag	OMS.Shipping_List	bit
LeadTime	___	int
CompleteRecord	___	bit

Table 9.21 – Company X's FactOnlineSalesE2E fields, data sources and data types

FactTransportation Fields	**Data Source**	**Data Type**
FK_CreateDate	OMS.Orders	int

PickupDateKey	WMS.Orders_Item; Shipping Company Y Excel File	int
DeliveryDateKey	WMS.Orders_Item; Shipping Company Y Excel File	int
FK_Product	RMOS.Product_Desc	int
StoreKey	RMOS.SalesOrderHead	int
DeliveryStoreKey	OMS.Orders	int
SupplierStoreKey	OMS.Shipping_List	int
PrepAddressKey	OMS.Shipping_List	int
DeliveryAddressKey	OMS.Address	int
FlowKey	OMS.Orders	int
StatusKey	OMS.Shipping_List	int
ShippingCompany	OMS.Orders	nvarchar(50)
OrderUnitNumber	OMS.Orders	nvarchar(50)
OrderNumber	OMS.Orders	nvarchar(50)
TrackingNumber	OMS.ShippingManifest; WMS.LPN	nvarchar(50)
AggregationTrackingNumber	WMS.LPN_Output	nvarchar(50)
CreateDate	OMS.Orders	datetime
ExpeditionDate	OMS.Shipping_State_History; WMS.Orders_Item	datetime
PickupDate	WMS.Orders_Item; Shipping Company Y Excel File	datetime
ShippingCenterEntranceDate	Shipping Company Y Excel File	datetime
OutForDeliveryDate	Shipping Company Y Excel File	datetime
DeliveryDate	WMS.Orders_Item; Shipping Company Y Excel File	datetime
CancelMoment	OMS.Orders	datetime

ExpectedDeliveryDate	WMS.Orders_Item; Shipping Company Y Excel File	datetime
PreOrderFlag	OMS.Orders_Item	bit
MultiMonoFlag	OMS.Shipping_List	bit
LongtailFlag	Longtail Excel File	bit
SuccessFlag	WMS.Orders_Item; Shipping Company Y Excel File	bit
LeadTime	___	int
LastOccurence	Shipping Company Y Excel File	nvarchar(50)
CompleteRecord	___	bit

Table 9.22 – Company X's FactTransportation fields, data sources and data types

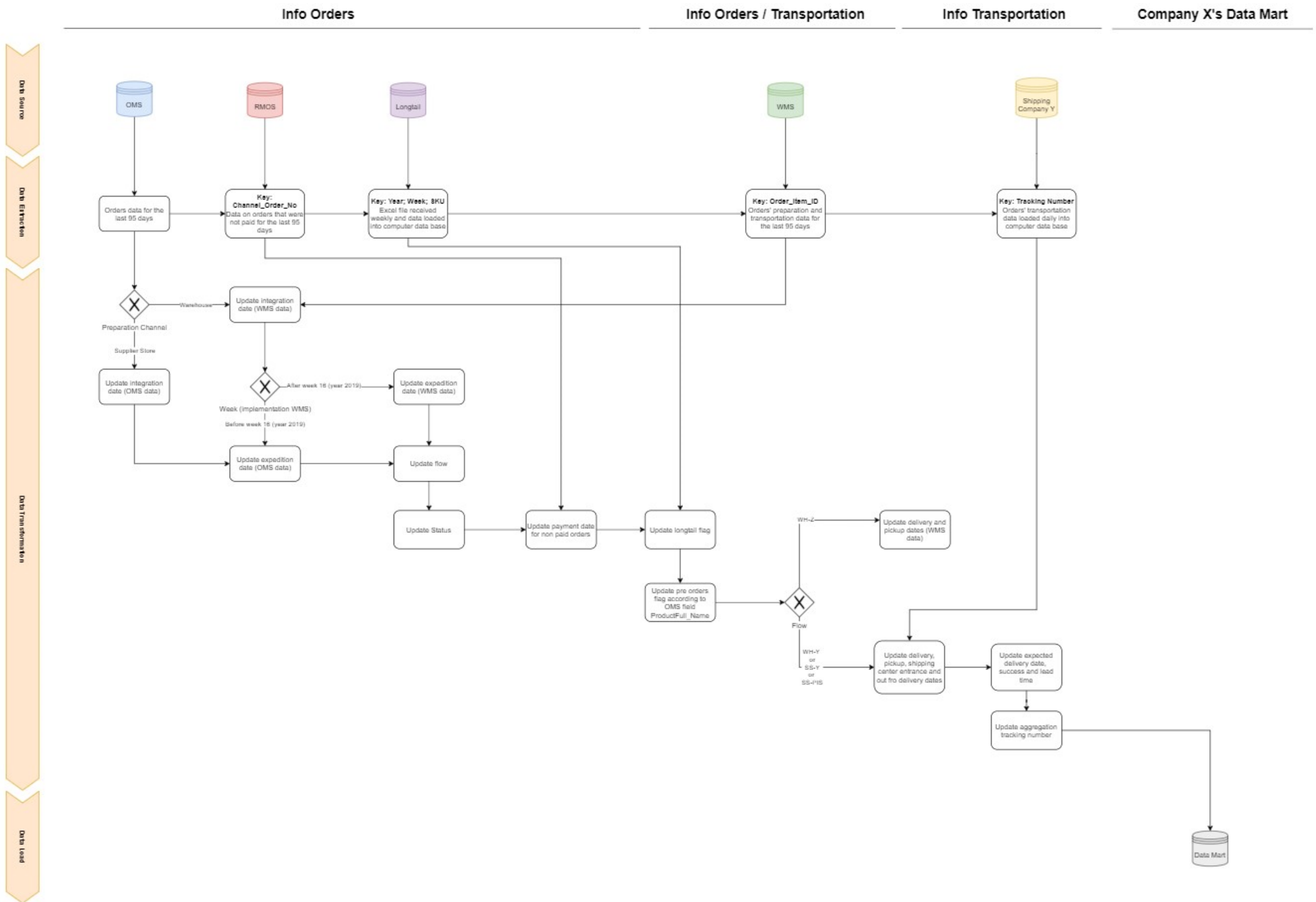

Figure 9.7 – Summary of ETL process

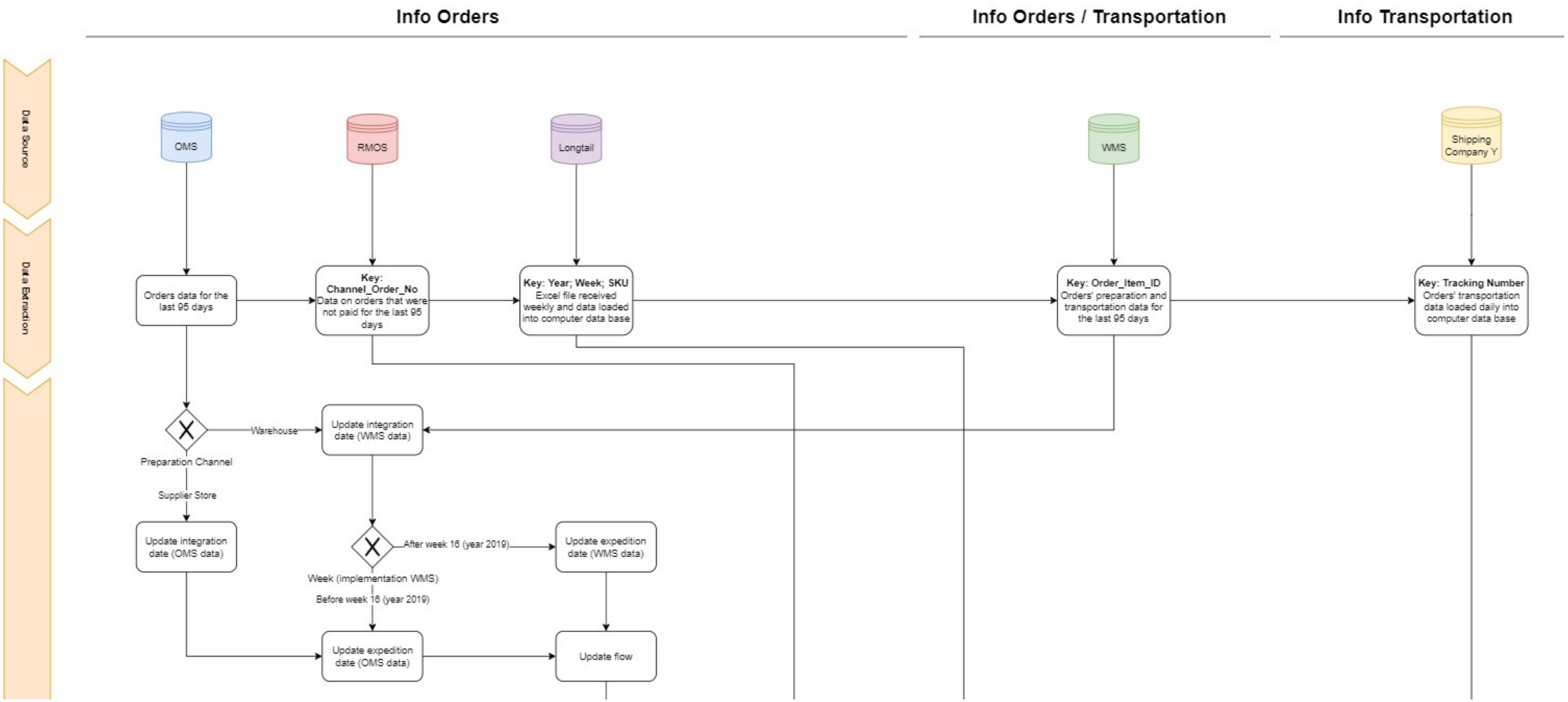

Figure 9.8 – Summary of ETL process (zoom)

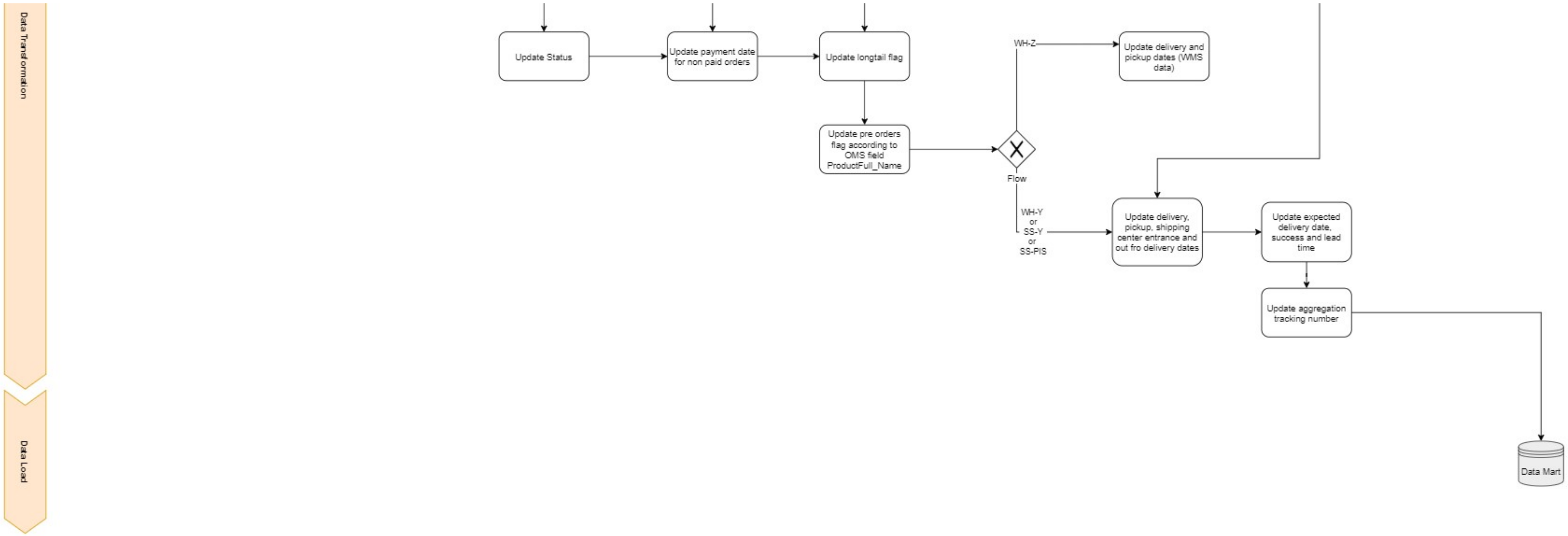

Figure 9.9 – Summary of ETL process (zoom)