Logistics Network Optimization

UPS Portugal Access Point Case Study-Lisbon Area

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Abstract

Modern global markets are characterized by fast pacing and dynamic processes, which sets pressure to companies' supply chains, in continuous searching for operational improvements. In addition, customers' empowerment, through globalization and e-commerce has been shifting the distribution paradigm. Thereby, companies are unceasingly on the hunt for efficiency enhancement opportunities, often targeting critical and costly activities, such as transportation and distribution.

In this context, the current project focus on a leading logistics' provider, UPS Portugal, with closer look to last-mile logistics model. The company wants to optimize its logistics network, by adding a new level to the grid, placed closer to final customer. This infrastructure, named UPS Access Point aims to reduce reverse logistics complex processes and at the same time, improve the network's convenience and flexibility.

After problem description and a thorough literature review, all necessary data is gathered and evaluated in order to develop a solid solution for UPS Access Point network design. The optimum solution cost-wise is assessed towards UPS customer's requirements leading to the suggested solution that suits better UPS. Finally, a sensitivity analysis and a critical overview on the solution lay the foundations for the conclusions and future work proposes that can extend the research on the current topic of Last-Mile Logistics, addressed in this work.

Keywords: *Supply Chain Management, Last-Mile Logistics, Location-Routing Problem, Reverse Logistics, Cross-Docking, UPS Access Point.*

Resumo

Os mercados globais modernos são caracterizados por processos dinâmicos e de ritmo acelerado, que exercem pressão sobre as cadeias de abastecimento das empresas, numa procura contínua por melhorias operacionais. Além disso, o fortalecimento de poder dos clientes, através da globalização e do comércio eletrónico, tem vindo a alterar o paradigma da distribuição. Deste modo, as empresas estão constantemente à procura de oportunidades de melhoria de eficiência, frequentemente tendo como alvo atividades críticas e dispendiosas, como o transporte e distribuição.

Neste contexto, o presente projeto debruça-se sobre uma empresa líder de serviços de logística, a UPS Portugal, com mais atenção no seu modelo de logística *last-mile.* A empresa pretende otimizar a sua rede de logística, através da introdução de um novo nível na rede, localizado mais perto do consumidor final. Esta infraestrutura, conhecida como UPS Access Point pretende reduzir os complexos processos de logística inversa e ao mesmo tempo, melhorar a flexibilidade e conveniência da rede.

Após a descrição do problema e uma meticulosa revisão literária, estão reunidos e analisados todos os dados necessários para o desenvolvimento de uma sólida solução de design da rede de UPS Access Points. A melhor solução de um ponto de vista de otimização de custos é avaliada contra os requisitos da UPS para satisfação dos clientes, levando a uma solução que sugere melhor adequação às necessidades da UPS. Finalmente, uma análise de sensibilidade e um *overview* crítico sobre a solução criam a estrutura para as conclusões e trabalho futuro que podem estender o espaço para a investigação sobre o tópico de Logística de *Last-Mile*, abordados neste trabalho.

Palavras-Chave: *Gestão de Cadeias de Abastecimento, Logística de Last-Mile, Problemas de Localização-Rotas, Logística Inversa, Cross-Docking. UPS Access Point*

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List of Abbreviation and Acronyms

3PL- Third-Party Logistics

APNID – UPS Access Point Need ID

APS- Automated Parcel Stations

B2B- Business to Business

B2C- Business to Consumer

C2C- Consumer to Consumer

CAP - Fixed cost associated with the installation of UAP point of sale

CEP – Courier, Express & Parcel

CpP – Cost per Package delivered

CpPAP – Special Cost per Package delivered at UPS Access Point Location

CpS – Cost per Stop

CpSAP – Special Cost per Package delivered at UPS Access Point Location

CSCMP –Council of Supply Management Professionals

DWS – Dimensions-Weight Scan

ETA – Expected Time of Arrival

ETD – Expected Time of Departure

FTL- Full Truck Load

GDP – Gross Domestic Product

IPC – International Post Corporation

LRP – Location Routing Problem

LTL – Less than Truckload

NCI – Network Convenience Index

ODM- Original Design Manufacturing

OEM- Original Equipment Manufacturing

OSP – Outside Service Provider

RFQ – Request for Quotation

PP- Pick-up Points

PSI – Proximity Satisfaction Index

SC – Supply Chain

SCM- Supply Chain Management

SCS – Supply Chain Solutions

UAP – UPS Access Point Location

VRP – Vehicle Routing Problem

X2C- Aggregates B2C and C2C

1. Introduction

1.1. Problem contextualization

The rise of e-commerce has been boosting online retail and contributing to shaping new consumer habits. E-business is more customer-oriented, since buyers are more demanding and empowered. Therefore, companies operating online are feeling the pressure on their supply chains. On one hand, it is imperative to improve efficiency on the last-mile segment, which has been increasing complexity with individual home deliveries. On the other hand, customers request greater flexibility, when dealing with deliveries and pickups. As can be seen in figure 1 the online retail globally is forecast to grow 3.5 times the rate of gross domestic product (GDP).

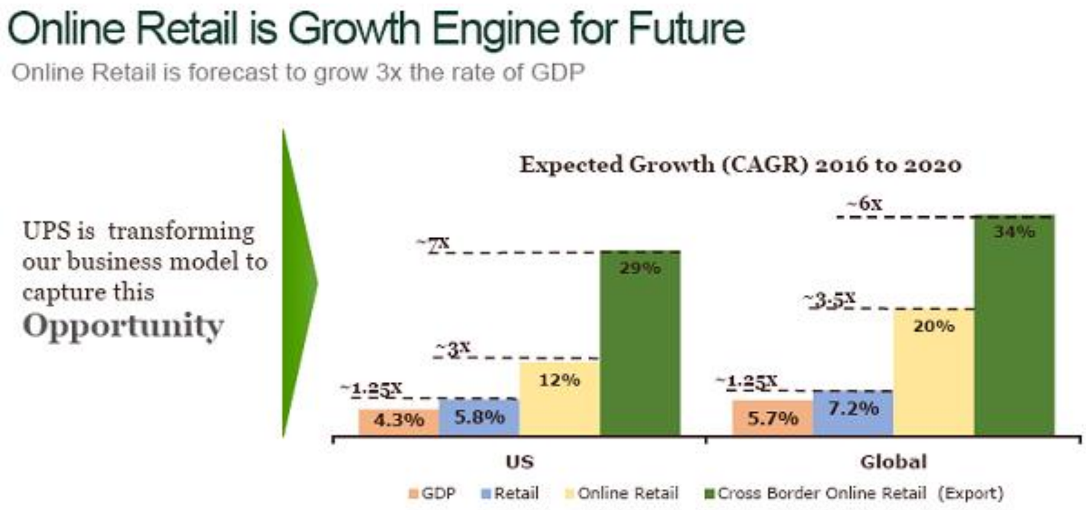

Figure 1- Online Retail Expected Growth. ***Adapted from UPS (2017c)***

The work to be developed along with UPS Portugal comes from the necessity of restructuring the company's logistics network in Portugal. UPS seeks to implement their Access Point strategy as drop-off or pickup locations. By the end of 2016 UPS Access Point Network accounted 27,000 different locations worldwide. This strategy is already implemented and growing in countries like US, Canada, Mexico but also in Europe, from Spain, France, Germany, UK, Italy, Poland, Austria, Luxembourg, Nederland and Belgium. UPS Access Point Network was developed to face the increasing demand of e-commerce. Thus, UPS is transforming their business model and more capacity and flexibility were key aspects. They profiled their costumers has "on-the-go" shoppers. In order to improve e-commerce capacity, flexibility and service level, UPS created Access Point Network. This is a flexible network that provides convenient delivery or pickup locations alongside with small business stores. To achieve this, UPS establishes partnerships with small business stores and creates a win-win situation where they install an Access Point at the store, taking advantage of weekend and evening hours and in return more customers and a small fee are expected. The location of Access Points is strategic according to customer's density.

1.2. Thesis objectives

The main objective for this work is the study of UPS logistics network in Portugal, in order to implement the best UPS Access Point network in the Lisbon area. In this sense, a theoretical approach is important to analyse what has been studied in current literature and find the foundations and methodologies to address the problem. To achieve end result is imperative to focus on the following goals:

- Characterize UPS logistics network in Portugal.
- State of the art review, with special focus on methodologies for problem solving.
- Analysis and description of last-mile logistics models.
- Evaluate UPS Access Point network implementation.
- Determine UPS Access Point locations.

Final decision about the acceptance and implementation of any suggestion relies on UPS.

1.3. Research Methodology

The research methodology implemented in current work aims to provide better understanding on the problem of UPS Portugal last-mile logistics and possible solution, as well as to afford future developments related with last-mile logistics in CEP market. The conceptual framework model followed by this work is based on the investigation manual by Quivy and Campenhoudt (1995). According to the authors, a scientific investigation must hold three distinct phases: ***Rupture*** - The first stage to start investigation, which holds the stages for starting question, to identify the problem and the exploration stage, through literature review; ***Construction*** - Step to build the analysis model; ***Verification*** – Final stage must focus on the observation of the results obtained by the model implementation, as well as all the analysis information and final conclusions. The only modification to Quivy and Campenhoudt (1995) model was the interchange between stage 2 and stage 3 (see Figure 3, highlighted with green). Thus, this project starts by doing the contextualization of the problem and then, the literature review to explore the main topics.

A relevant feature of the present model is that scientific research is not just straight dynamic in one direction, and often retroactive mechanisms (see figure 3, i.e., stage2-stage1 connection) are necessary to better accommodate the relationships between stages. Stages 1 holds the starting question activity. The intent is to provide a starting point to address the problem from the best perspective possible. Next, stage 3 seeks to bring deeper understanding about the problem itself and all dependent variables. Stage 2 holds the state of the art that will give support to next steps. Stage 4 clarifies the LRP optimization model, with respective variables and constraints. Afterwards, stage 5 aggregates a set of operations that will run the model with real data and intermediate the connection with stage 6, where results are compared with expectations or hypothesis, to perform an empirical verification. The final stage 7 holds the main conclusions and contributions to the problem under investigation. Stages 4 to 7 will be addressed in the master's thesis section.

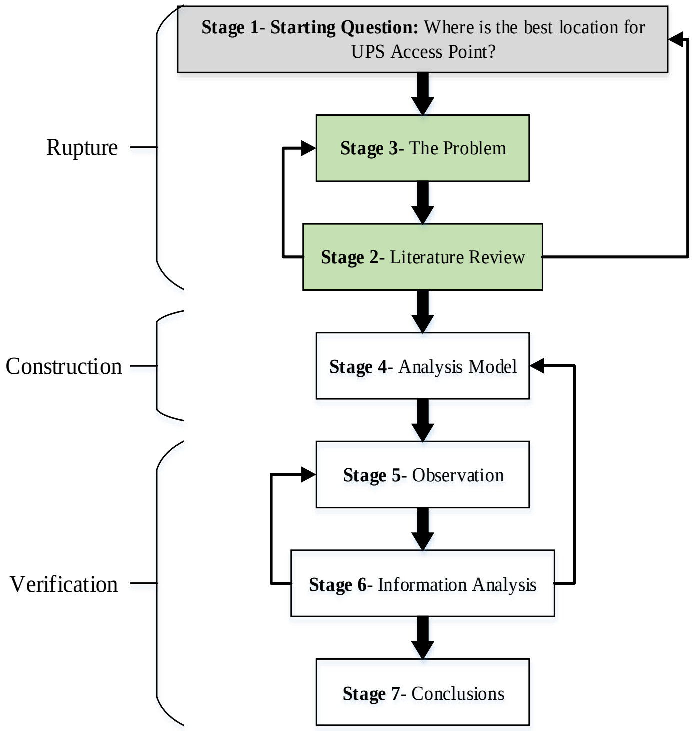

Figure 2- Research methodology framework. ***Adapted from Quivy and Campenhoudt (1995)***

1.4. Thesis structure

The current Thesis´s structure is organized in six main chapters, divided according to the following framework displayed in figure 3.

First three chapters lay the foundations to start addressing the problem, by clearly identifying the problem and the objectives aligned with project development, presenting context to UPS supply chain network and operation and finally, creating a solid literature review to sustain case study resolution.

After setting the groundwork, Chapter IV presents all data processing and forecasting necessary for case study resolution that is developed in Chapter V.

Finally, Chapter VI brings some closure to the work, giving relevant conclusions and potential future work that can extend the research and help UPS implement Access Point distribution network and thus, optimize its operation and results.

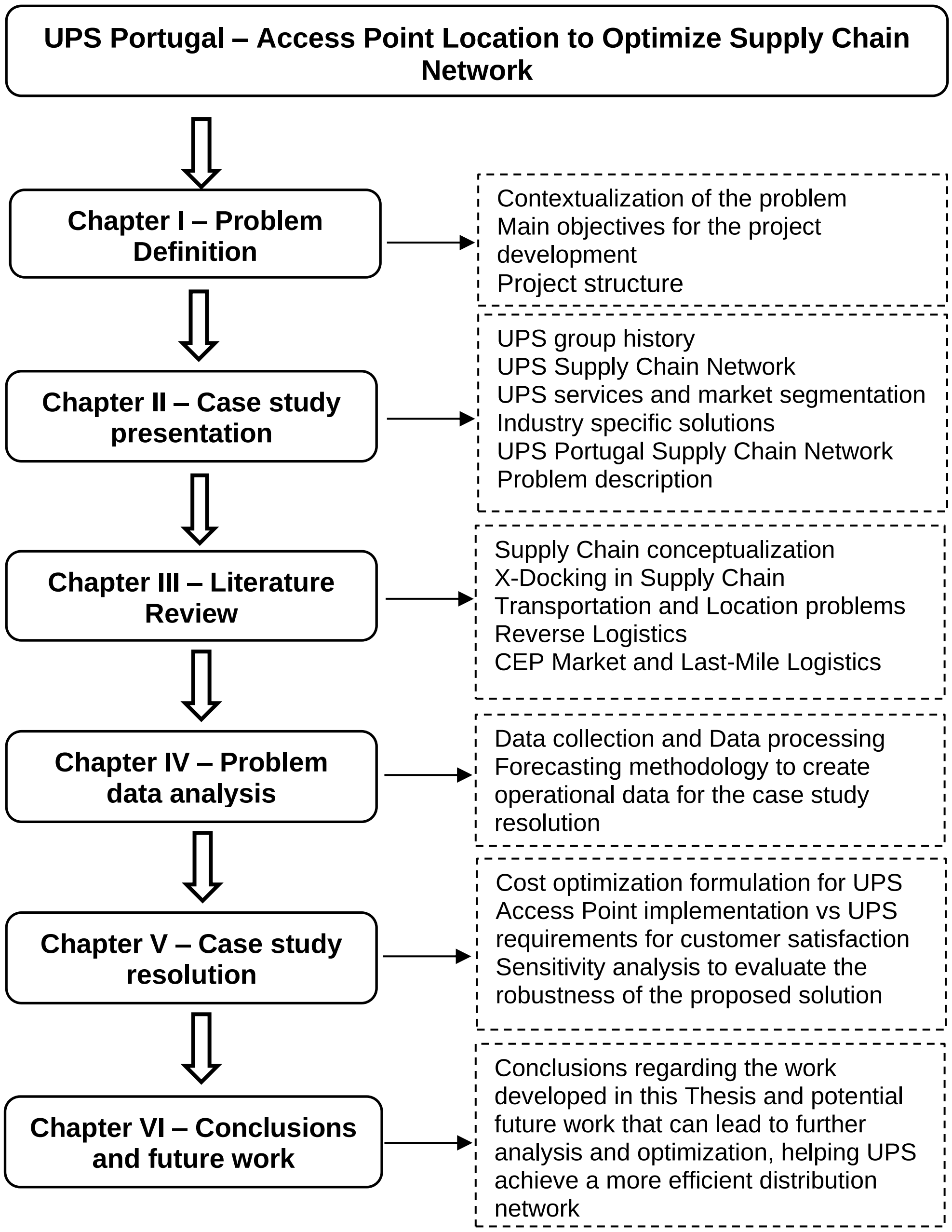

Figure 3- Methodology and Thesis structure framework

2. Case Study: UPS Access Point Network (Lisbon)

UPS is one of World's biggest freight forwarders and has been trying to shape its supply chain to cope with the pressure done by increasing e-commerce. For that reason, UPS is always looking for continuous innovation and has been pushing improvements specially on the last-mile level. The most recent advance was the implementation of Access Point in many different countries. In order to understand the benefits of bringing Access Point network to Portugal, this chapter intends to provide context to case study problem. First, UPS activities as a group will be depicted, with special detail for the services portfolio and strategic operation areas. Afterwards, further drill down is presented for UPS activity in Portugal, in particular at Porto and Lisbon Hubs. The activities integrated in Portuguese supply chain will be detailed, with special interest in urban last-mile logistics.

2.1. UPS Group

2.1.1. UPS History

UPS was founded in a Seattle basement by two young entrepreneurs, Claude Ryan and Jim Casey in 1907. The company was registered as American Messenger Company (AMC). At the time, the west part of the United States was undeveloped, and the service-based companies started to emerge. Sawing this market opportunity AMC presented a range of solutions for these new service businesses, from simply running errands to making home deliveries for drugstore customers. In 1919, the company changed the name to United Parcel Service (UPS), as an indicator of the type of service provided. Air service was first introduced around 1929, but it was forced to early shut down two years later due to an economic recession. Even so, air service was reintroduced in 1953, and has been a success ever since.

After consolidating its operation in the United States, UPS turned its aim to new growing opportunities. Soon was clear that internationalization and air service development were the next steps for the company. Thus, in 1975, UPS went international offering its services in Toronto, Canada and reaching Europe in following years. Air delivery business was increasing in the 1980s, so UPS decided to reinforce its position in the sector and launched in 1988, UPS Airlines. Nowadays, it is one of the largest airlines for common carrier and special package deliveries. Throughout its integrated network in over 220 countries, UPS is responsible for more than 15 million packages each business day (UPS, 2017b).

The 1990s brought the boom of the E-commerce. Companies and consumers were changing the way of doing business in a global and dynamic market connected with internet. The 2000s marked the necessity for a supply chain management business area. More and more, customers were looking for expertise to improve efficiency in their own supply chains. Thus, UPS introduced Supply Chain Solutions, providing from 3 rd party logistics solutions to global freight and financial advisory to its customers supply chains. UPS understood the growing importance of e-commerce in its delivery's model business. Therefore, launched an innovative home delivery system named UPS My Choice, lending over more power to customers to control their packages. In order to optimize driver routes and thus, improve operational results, UPS launched ORION, On-Road Integrated Optimization and Navigation system. This is a continuous improvement program that intends to improve efficiency on ground freight. Another important milestone was the development of UPS Access Point network. It is an alternative network to home delivery service that allows customers to choose more convenient locations for drop offs or pick-ups.

Throughout the years, UPS kept its policy of acquisitions to improve capacity and know how. In 1999, UPS took over Challenge Air, becoming the biggest express and air cargo company in Latin America. Another important acquisition took place in 2004, when UPS purchased Menlo Worldwide Forwarding, improving heavy air freight capacity. In 2012, UPS acquired Kiala to expand B2C presence, and later in 2015, acquired Coyote Logistics to improve truckload freight brokerage (UPS, 2017b).

2.1.2. UPS Supply Chain Network

UPS operates one fully integrated supply chain network (UPS, 2017c). This complex network is built on four main operations including transportation, sorting, delivery and reverse logistics, as portrayed in figure 4. In addition to that, there is a state-of-the-art logistics base named UPS Worldport.

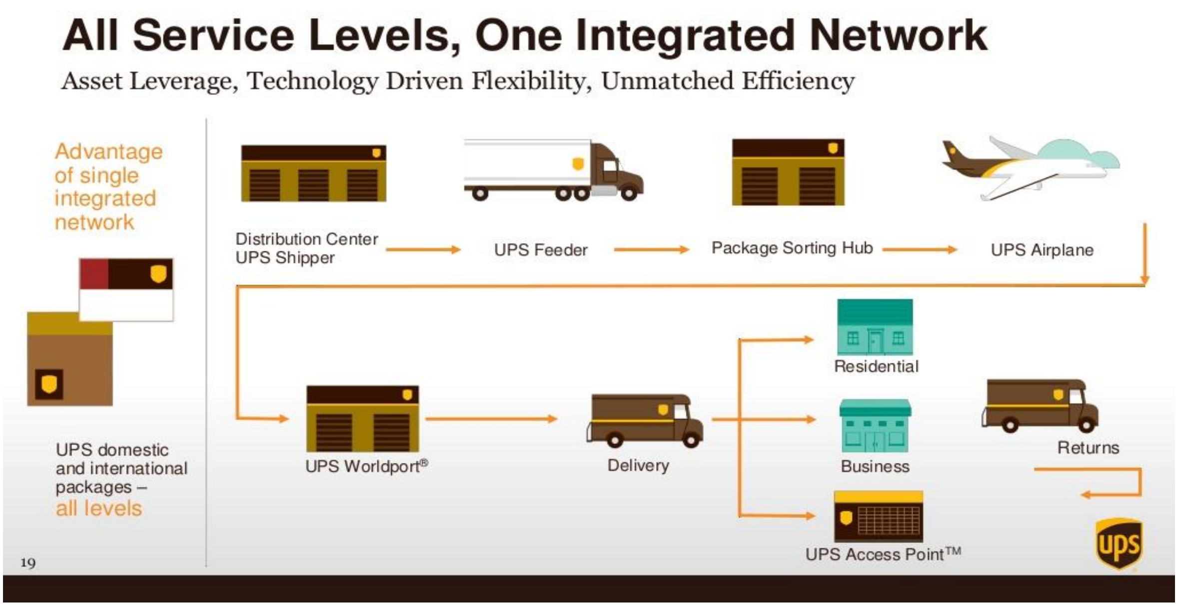

Figure 4- UPS Supply Chain Network. ***Adapted from UPS (2017c)***

- **Transportation**

  Include all the steps in the supply chain network dealing with any source of package dislocation with exception for delivery and returns. From the UPS feeder, responsible for package transportation between distribution centres and local sorting hubs to UPS air delivery business, making the connection between UPS Worldport and international sorting hubs.

- **Sorting**

  This activity takes place at local sorting hubs and UPS Worldport. It is a critical activity for operational efficiency and hub automation is referred by David Abney, UPS CEO, as one of the main strategic investments. Through a combination of high-speed conveyors, smart labels technology and advanced information system the packages are sorted according to zip code and delivery urgency.

- **Delivery**

  Delivery process, as depicted in figure 4, can be residential, business or through UPS Access Point network. UPS aggregates demand by zip code at distribution centre level and then sends full truck loads to deliver the packages.

- **Reverse Logistics**

  The final step in UPS supply chain network is reverse logistics. It includes all the returns made by customers. This is an important step for customer service level although it adds no value to the supply chain.

- **UPS Worldport**

  UPS Worldport is the main logistics facility for air transportation with 5,200,000 square feet. It is located in Louisville International Airport and is the largest capital investment ever made by UPS. Worldport latest expansion took place in 2010 with a capital investment of 1 billion dollars. Worldport sort capacity is currently 416,000 packages per hour and it has a total of 70 aircraft docks. UPS Worldport air hub has special features that allow significant efficiency improvements. These features include high-speed conveyors and smart labels technology. Besides, there are 546 camera tunnels for package scanning. This automated sorting process allows UPS to divide the products in three main categories: documents, small packages and irregular sized packages. Furthermore, it allows overall package cycle-sorting reduction (UPS, 2017d).

2.1.3. UPS market segmentation & services

UPS market is organized in three main segments: U.S. Domestic Package, International Package and Supply Chain & Freight. The main source of revenues is the U.S., accounting for 79% (see Figure 5). The revenue segmentation reveals that U.S. Domestic Package is the strongest segment. However, International Package segment took the second consecutive year of double-digits growth, with an increase of 13.2% for total adjusted operating profits (UPS, 2017a). At last, Supply Chain & Freight segment as also increased revenues, mainly because the acquisition of Coyote Logistics and good performance in strategic areas within Logistics segment, such as Healthcare, Retail and Aerospace (UPS, 2017a).

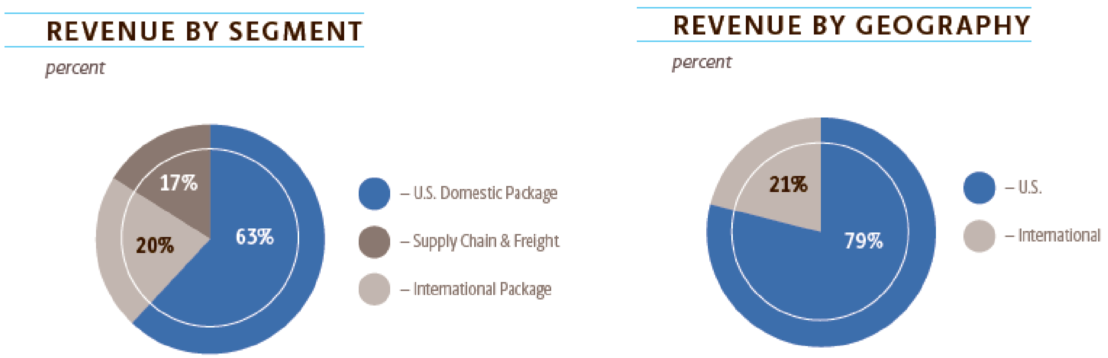

Figure 5- UPS revenue by segment (left) and by geography (right). ***Adapted from UPS (2017a)***

UPS offers a broad portfolio of services, ranging from specific freight solutions to air and ground transportation operations. Besides, these services are complemented with more specific supply chain solutions that incorporate 3PL operations, as well as customs and financial expertise. Figure 6 illustrates UPS services for each market segment.

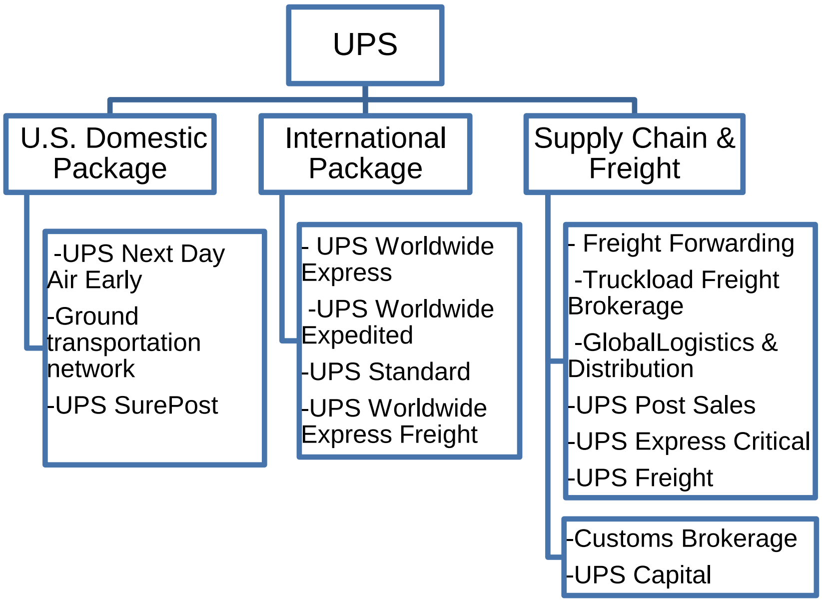

Figure 6- UPS market segments and respective services. ***Adapted from UPS (2017a)***

U.S. Domestic Package Segment

U.S. Domestic Package Segment, as previously stated, accounts for 63% of UPS revenues. Therefore, UPS air and ground shipping network offers competitive and differentiated services.

- UPS allows customers a full range of delivery schedule options, from same day to three days. To customize its services, UPS enable customers to specify a time-of-day to make the delivery.
- UPS Next Day Air Early is a fast and efficient service, which gives customers the option for early delivery times from 8:00 A.M. to 2:00 P.M.
- UPS is the U.S. leader for ground small package delivery. Thus, UPS has developed a full ground shipping network that can answer customer's necessities across the U.S. The average daily package volume for U.S. is 13.5 million with delivery time within one to three business days. In addition, UPS SurePost is a residential ground service, specialized in non-urgent lightweight packages. The delivery process is assured through a partnership with U.S. Postal Service.

International Package Segment

UPS International Package Segment is responsible for small package operations in Latin America, Canada, Europe, Asia-Pacific, Indian sub-continent, the Middle East and Africa. International segment is "the best long-term opportunity" as UPS CEO David Abney mentioned in his message to shareholders

(UPS annual report 2016). Therefore, UPS presents a wide range of Express delivery services with day and time assurances.

- UPS Worldwide Express is a fast one-to-three day shipping service and is currently available in 118 countries. On the other hand, UPS Worldwide Express Plus is a special express service with guaranteed next morning delivery for rush shipments. This service is currently available in 56 countries.
- UPS Worldwide Expedited targets customers who seek an alternative to Express services. However, UPS Worldwide Expedited is also a guaranteed delivery day service.
- UPS Standard is a specialized service for cross-border ground package delivery. It is currently operating in Europe, between U.S. and Canada and U.S. and Mexico borders.
- UPS Worldwide Express Freight is a specialized door-to-door service for palletized shipments over 150 pounds. Once again, is a one-to-three business day shipping service and is currently in 66 origin countries and 64 destinations.

Supply Chain & Freight Segment

Supply Chain & Freight Segment meets demand for global companies with complex supply chains. Thus, it offers a wide range of services from transportation and distribution to international trade and brokerage. Besides, UPS Capital offers financial solution.

- Freight Forwarding incorporates a wide range of global air freight services and non-vessel operating common carrier services between most major ports around the world.
- Global Logistics and Distribution is the sub-segment that incorporates all the 3PL and specific distribution services, throughout UPS global supply chain network. In 2016, UPS acquired Marken, a global provider for healthcare solutions. This acquisition was part of a larger strategic operation that allowed UPS to expand its healthcare logistics services. UPS currently owns a global network for healthcare industry, capable of dealing with temperature-sensitive logistics.
- UPS Post Sales is a specialized service for service parts logistics and reverse logistics. Customers can use UPS global supply chain network in order to guarantee post-sales services in their own supply chains. On the other hand, UPS Express Critical is a very specific service for time-sensitive and high-value goods.
- UPS Freight offers less-than-truckload (LTL) and full truckload (FTL) services, taking advantage of one integrated supply chain network.
- Complementary Brokerage services are included in UPS Truckload Freight Brokerage and UPS Customs Brokerage, while financial and insurance solutions are covered by UPS Capital.

2.1.4. Competitive Investment Position

Modern times are pressuring CEP players and retailers to expand capacity and modernize supply chain networks. Either by increasing E-commerce or changing consumer behaviour, truth is that delivery companies are scaling up and pursuing a heavier fixed cost structure. In addition, traditional E-Tailers, which are retail businesses selling goods on-line, are breaking into CEP market and competing for delivery. Companies like Alibaba group or Amazon used to rely on CEP industry for parcel's delivery. However, they saw the multibillion-dollar market opportunity and decided to compete. All these pressures lead to large capital investments, as portrayed in Figure 7.

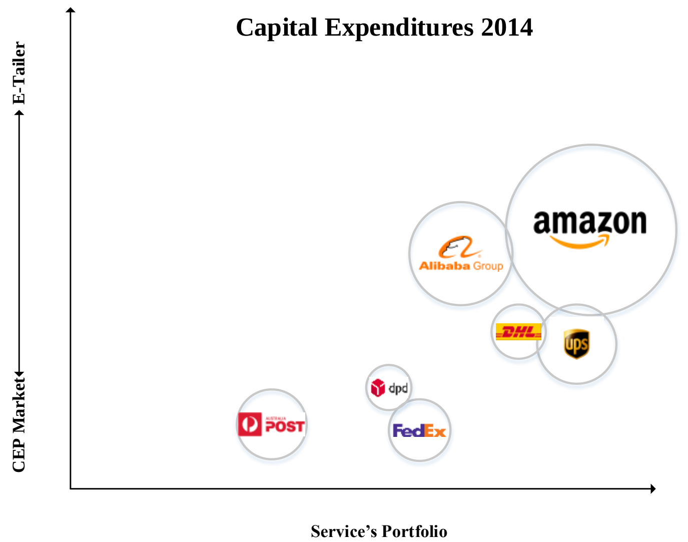

Figure 7- Capital expenditures on parcels 2014. ***Adapted from Accenture (2015)***

There is no longer a defined line separating traditional e-Tailers from CEP market, which contributes to fearless competition. Up to 2014, Amazon has spent $13.9 billion since 2010 on infrastructures, including 13 parcel depots in U.K. On the other hand, Alibaba group has gathered $4.5 billion from its own equity and private investors to develop its logistics network in China. Both companies present a broad portfolio of services, ranging from pure B2B platforms, to B2C and even up to logistics services. UPS is investing $2 billion in a period of 5 years to improve its international facilities, targeting the development of E-commerce. Now DHL invested around $890 million to expand and automatize its parcel distribution network, with focus in Germany. Both UPS and DHL present broad and similar service's portfolio, extending from traditional parcel delivery, to warehousing, 3PL and customize supply chain solutions. On a slightly different mode, FedEx and DPD operate mainly in the Expresso and Parcel segment. FedEx invested $1.2 billion to expand FedEx Ground branch, that offers ground shipping services. Although this current investment comparison is made until 2014 (see Figure 7), it is important to mention that FedEx managed to acquire TNT Express in 2016 and is now the World's giant for the express segment. On the other hand, DPD, which brings together an international network with Chronopost and SEUR, has invested up to $13.6 million to improve B2C capacity. Australia Post made investments around $1.5 billion to double its capacity at Sidney and Melbourne hubs. From Figure 6 can be noticed that Australia Post is on the left corner of service's portfolio because its services are mainly focused in post and small parcel distribution. After a first overview to the capital expenditures in parcel's segment, is now relevant to detail what areas besides capacity UPS is investing. Thereby, the following subsection performs a deeper analysis to UPS strategic capital investment areas.

2.1.5. Industry Specific Solutions

UPS offers differentiated solutions to accommodate the specific necessities of aerospace, automotive, industrial manufacturing, retail, professional and consumer services, healthcare and high-tech businesses. Figure 8 identifies the main challenges of each specific industry sector, as well as potential market opportunity.

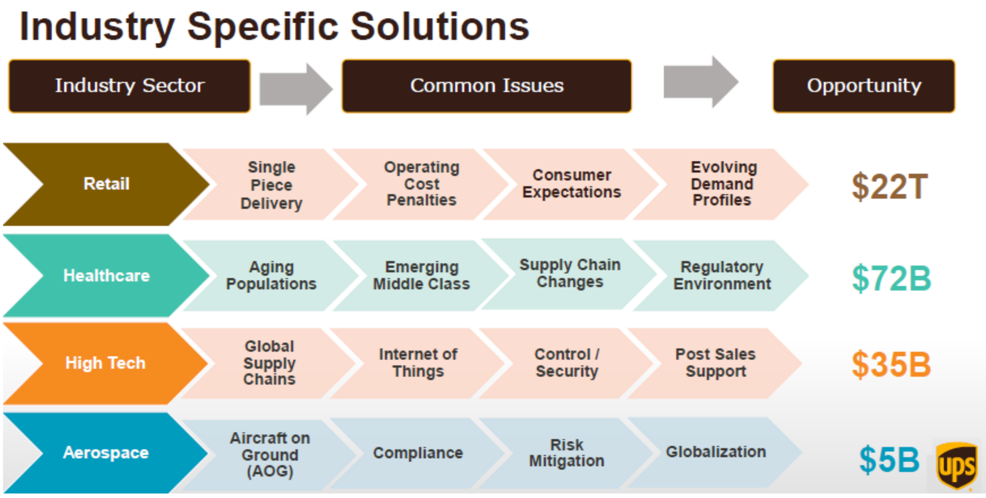

Figure 8- UPS Industry Specific Solutions. Adapted from *UPS (2017d)*

Retail Business

Retail sector is very dynamic and is important to develop a supply chain network capable to deal with constant evolving demand profiles. Retail industry sector presents a market potential opportunity of $22 trillion.

Healthcare Business

Healthcare industry is a strategic business for UPS. The combination of increasing demand for healthcare, constant product innovation, increasing regulatory control and decreasing return on investments is creating serious difficulties to existing healthcare firms. Therefore, UPS has expanded its healthcare capabilities and in 2016, acquired Marken, a global provider of supply chain solutions to the life science industry. The healthcare market potential is $72 billion. Despite the market potential is less than retail business the competition in healthcare logistics is also smaller, due to all the constraints for security. Healthcare business deals with extremely temperature-sensitive products and regulatory compliance is required.

High Tech Business

High Tech industry is characterized by global supply chain networks, often with multiple suppliers and customers worldwide. This market segment represents a $35 billion opportunity for UPS, usually with high margin products. In addition to global networks, high tech market typically operates complex reverse logistics systems and requires security measures. In this sense, UPS recognizes enormous business opportunities and offers differentiated supply chain solutions.

2.2. UPS Portugal

2.2.1. Supply Chain Operation

UPS is currently operating in Portugal through two sorting hubs located respectively in Porto's airport and Lisbon, Prior Velho. From the European Air Hub, home for UPS international operation located in Cologne Germany, packages are sent to Oporto by plane on a daily-basis. These planes can accommodate 30 air cargo containers. In addition to air transportation, there is a daily road connection (1-3 FTL) Benavente-Porto and Benavente-Lisbon. Once the plane arrives at Porto's airport, the cargo tagged for Porto is transferred to UPS sorting facility, located at the back of the airport. The rest of the cargo remains at the airplane and UPS adds all packages tagged for Lisbon that arrived at Porto's sorting hub from local pick-ups. Then, the airplane flies to Lisbon. The ETA- Expected Time of Arrival at Lisbon airport is 7.05 from Tuesday to Friday and 6.45 at Monday, while ETD- Expected Time of Departure from Lisbon is 19.15, from Monday to Friday. The air cargo arriving at Lisbon contains at least 1 container from Porto, 1 container from EU Community countries and 1 container extra EU Community. All air cargo must be audited by a government certified company, through an x-ray machine. Both UPS Lisbon and Porto Hubs have external auditors.

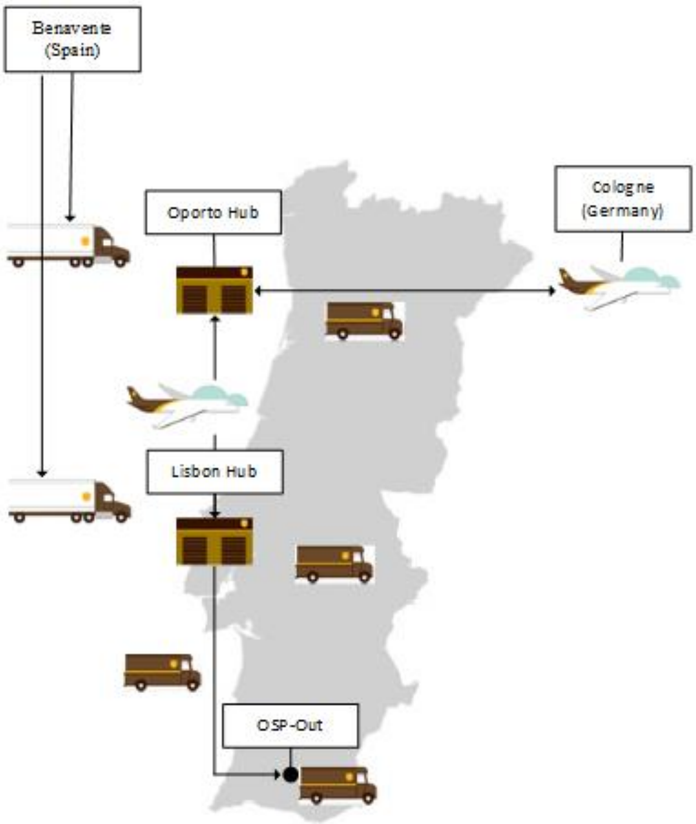

Figure 9- UPS Portugal Supply Chain Network. *Own elaboration*

When the airplane lands in Lisbon it is unloaded and the cargo leaves by truck to UPS Lisbon sorting hub. After sorting process, packages follow to delivery by local network (see Figure 9). The plane that arrives at Lisbon's airport, after being unload, is filled with packages tagged for Porto and International and now follows the inverse transportation route Lisbon-Porto. There, packages tagged for Porto are unloaded and International packages are added. Finally, the plane leaves again to International Air Hub in Germany. Figure 8 also depicts a connection between Lisbon hub and an outside service provider

(OSP-Out) warehouse, located in Algarve. Everyday 1 to 2 small FTL makes the connection between the two locations. The OSP-Out warehouse works as a X-docking aggregation point, where packages are combined according to delivery location.

2.2.2. Hub Infrastructure and Operation

2.2.2.1. Lisbon Hub

UPS Lisbon Hub is located in Prior Velho, near Lisbon airport. This is a strategic location since air transportation takes such a big impact in UPS logistics network. UPS Lisbon Hub holds UPS Supply Chain Solution (SCS) and UPS Small Package and operates an average of 5500 packages per day through importation and around 1500 packages for exportation. UPS Small Package deals with products up to 70 kg or 440 cm perimeter. Figure 9 captures UPS's Lisbon Hub logistics infrastructure.

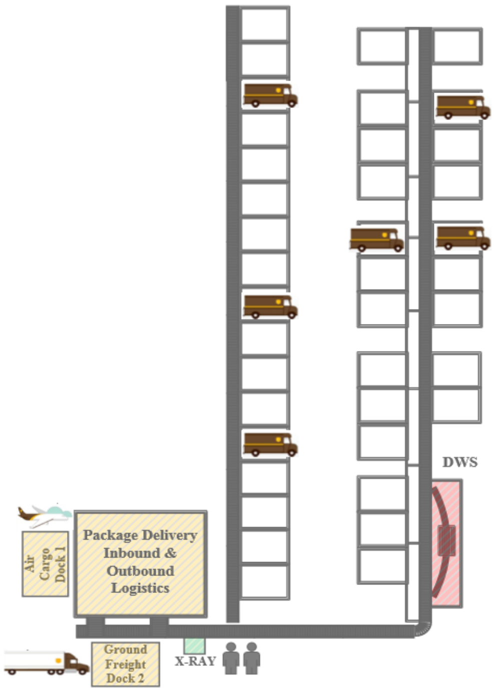

Figure 10- UPS Lisbon Hub Logistics Infrastructure. *Own elaboration*

Outbound Logistics

Packages with origin in inbound logistics are unloaded in dock 1 and 2 (see Figure 10). Dock 1 is exclusively for air cargo containers and is unloaded on the first floor. This floor holds ball bearings that allow the cargo containers to be moved around effortlessly. Dock 2 is used to unload FTL trucks on the ground level. Thus, there is a physic separation for air and ground operation (Figure 9, yellow area- 2 levels). Although there are distinct loading areas, according to the mode of transportation, once packages are unloaded, they will converge to the same conveyor belt, around the X-Ray area. Here, an operator is responsible for manual differentiation of packages, and pushes packages tagged for Lisbon area (Zip 1000) and Islands to the conveyor belt on the left. All other Zip references are left towards the conveyor belt on the right. As soon as packages reach the wright conveyor, each driver is responsible, first for picking the assign parcels, according to Zip code area and then, for organizing the packages in the back of the truck. After the truck is fully loaded, it leaves to perform deliveries and pickups.

Inbound Logistics

All the rectangle areas close to both conveyor belts are vehicle slots, where small trucks load their corresponding packages (see Figure 10). For reverse process, when packages are unloaded, coming from pick-up operations, it must be done exclusively on the conveyor belt on the right, to assure packages are scanned with DWS machine - Dimension, Weight, Scan, illustrated in Figure 9 by the red area. All parcels entering UPS network need to go through this device, in order to measure its exact size and weight. DWS is a critical machine for UPS operation and must be always running properly. The Inbound Logistics process is slightly different from Outbound procedure. All air cargo must go through X-Ray machine, to assure the safety of the plane. Instead of separating all air cargo from ground freight, UPS scans all packages with X-Ray. To avoid complexity between the two levels that separate air and ground cargo, the inbound operation is processed in cycles of air and ground freight. Whenever there is a change in the cycle, a big empty space is left on the conveyor, warning the loading operators that there is a cycle shifting and they need to readjust their positions to the corresponding level (1-air cargo, 2-ground freight).

2.2.2.2. Porto Hub

UPS Porto Hub is located in the back of Porto's airport. Once again, this is a strategic location that emphasises the critical role of air transportation in UPS logistics network. Besides that, Porto is the UPS connection between Portuguese and International operation. UPS Porto Hub runs an average of 6000 packages per day for importation and around 3000 to exportation. UPS's Porto Hub logistics infrastructure is more recent than UPS Lisbon Hub and has a new operation design, based on a single-level conveyor. Figure 11 portrays Porto's Hub operation infrastructure and it will be the object of further analysis.

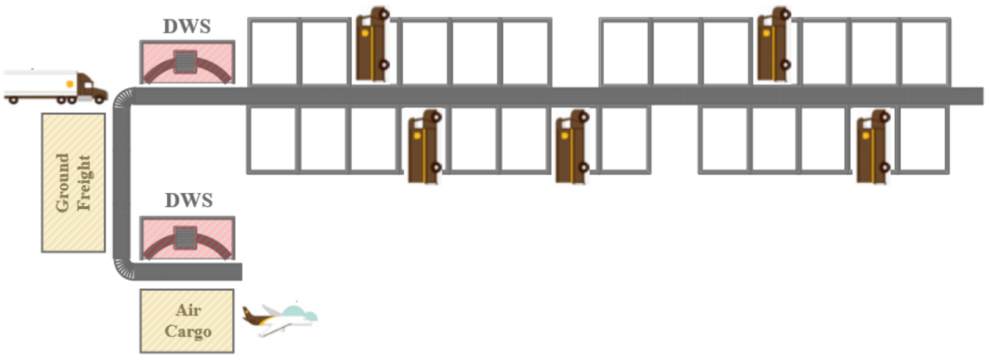

Figure 11- UPS Porto Hub Logistics Infrastructure. ***Own elaboration***

Outbound Logistics

Packages with origin in inbound logistics are unloaded in ground freight and air cargo docks, according to the mode of transportation. Parcels will enter the conveyor belt and will be expedited to the respective local delivery truck. Compared to Lisbon Hub, Porto does not require an operator to divide the packages between two different conveyor belts, since the entire operation is runned through a single conveyor belt.

Inbound Logistics

The inbound logistics operation is similar to Lisbon Hub, where all packages are unloaded to the conveyor belt and must go through the DWS machine, in order to register the real parcel's dimensions and weight. All inbound transportation is performed by airplane, so packages will be allocated to the air cargo location to be expedited (see Figure 11).

2.2.3. Last-Mile Urban Logistics

After describing the general model for UPS operation at sorting hub level, it is imperative to understand the last step in the logistics network. In this sense, current subsection will focus in last-mile operation system. The last-mile logistics operation take place from the moment each truck leaves UPS sorting hub to deliver its packages. Each vehicle has an assigned area, with specific Zip codes. As mentioned before, FTL trucks are loaded at UPS Sorting hubs, and must leave the facilities at most at 10 a.m. to start parcel's delivery. UPS Portugal operates subcontracted pick-up and delivery fleets, leaving the complex urban last-mile logistics to three different independent operators. In addition, packages have different time intervals for delivery, i.e. express might have a time window until noon, while UPS standard can be delivered until 6 p.m. Subcontractors must manage the different time windows and vehicle routing problems. The cost structure related to last-mile subcontractors is based on delivery/pickup stops, but also the volume of packages that take part at each delivery/pickup stop. Besides these two variables, a failed attempt for delivery (usually unattended home delivery) is also considered as operational cost.

2.3. Problem Description

Computing together both UPS general services and investment strategies with UPS Portugal logistics network, it is easy to comprehend the problem under study. Growing e-commerce and consequent increasing demand for home/business deliveries keep pressure on UPS's supply chain network, as it constantly seeks for innovation and ways to reduce costs, but still improve network flexibility. In this sense, improvements that might reduce costs and upgrade supply chain optimization are constant drivers at UPS, and the main reason behind the current project.

2.3.1. Access Point Network Impact

Just like in many other countries, UPS wants to implement Access Point Network in Portugal. The end-goal is to create another level in the supply chain, closer to customer and redesign the urban distribution network. Figure 12 illustrates the current urban last-mile logistics on the left and future implementation of Access Point Network on the right. Each vehicle routing is rearranged if there is enough volume to consider the location of UPS Access Point. In addition, drivers are notified if they must go to the Access Point or straight to UPS sorting hub, depending if there are any packages. Whenever there are unattended home deliveries, packages can be transferred to the closest Access Point, avoiding the complex process of reverse logistics.

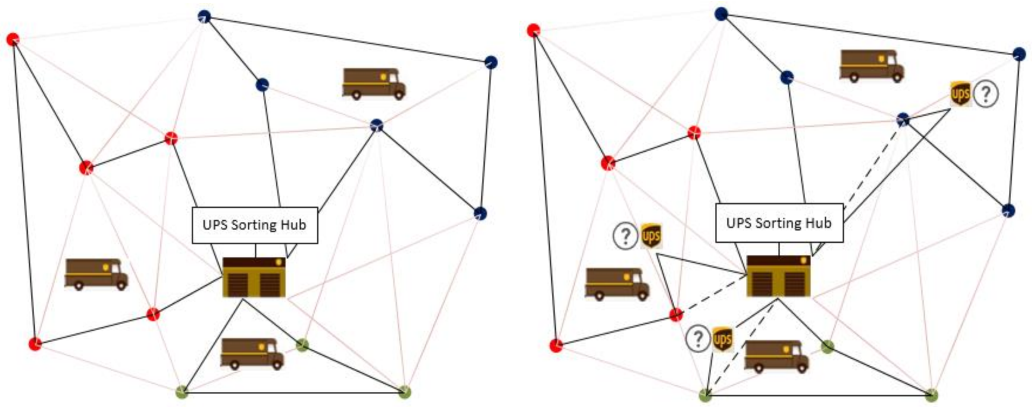

Figure 12- Access Point Network Design. ***Own elaboration***

To better understand the problem inherent to the current study, it is important to identify the main drivers for UPS Access Point implementation (see Figure 13).

- **Unattended home/business deliveries:** As mentioned before, e-commerce boom is constantly increasing local deliveries, and therefore the number of failed deliveries is also increasing. In short-term, the main consequence for unattended deliveries is a growing number of delivery retries. In the long-run however, there is an increase in reverse logistics volume.
- **Packages Returns & Sending:** Whenever a customer requests for package return/sending, a pickup must be scheduled. The main drawback is that customer might not be available during pickup schedule. Thus, packages return/sending lack in flexibility and can lead to customer's unsatisfaction.

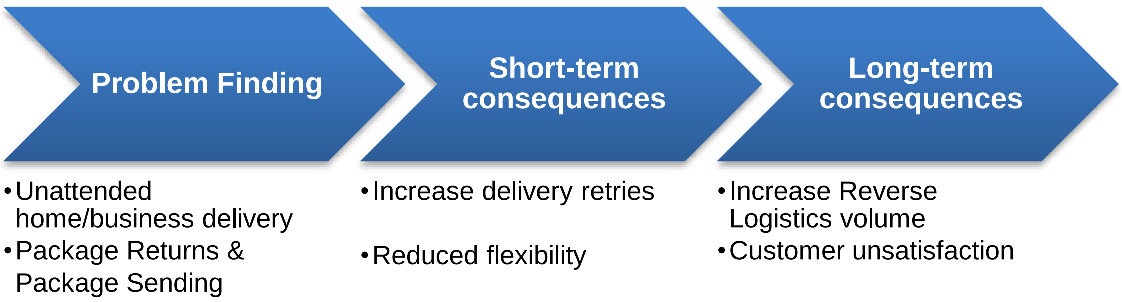

Figure 13- UPS Access Point drivers and consequences

2.4. Chapter Conclusions

The current chapter intends to provide context according to the scope proposed for the development of the present work. In this sense, first UPS group was characterized, including company's history and services' portfolio. Afterwards, other UPS features were examined, such as supply chain network, market segmentation, investment business model, industry differentiation, just to name a few. Furthermore, the problem under analysis is characterized, as well as the main drivers and consequences related with it.

3. Literature Review

3.1. Introduction

With the purpose of understanding the concepts associated with the case study of UPS Access Point Location, it is mandatory to perform a literature review, and analyse the evolution of supply chains (SC) and the specifications of the Courier, Express & Parcel (CEP) industry. To be able to present a solid solution for the subject of study, it is important to comprehend how the CEP market has been evolving and also, how cross-docking systems are implemented in SC. In addition, research is made on transportation modes and a drilldown to last-mile logistics, allows better understanding on how parcel delivery companies design their distribution network. The main concepts addressed in this chapter are organized in the following framework displayed in Figure 14.

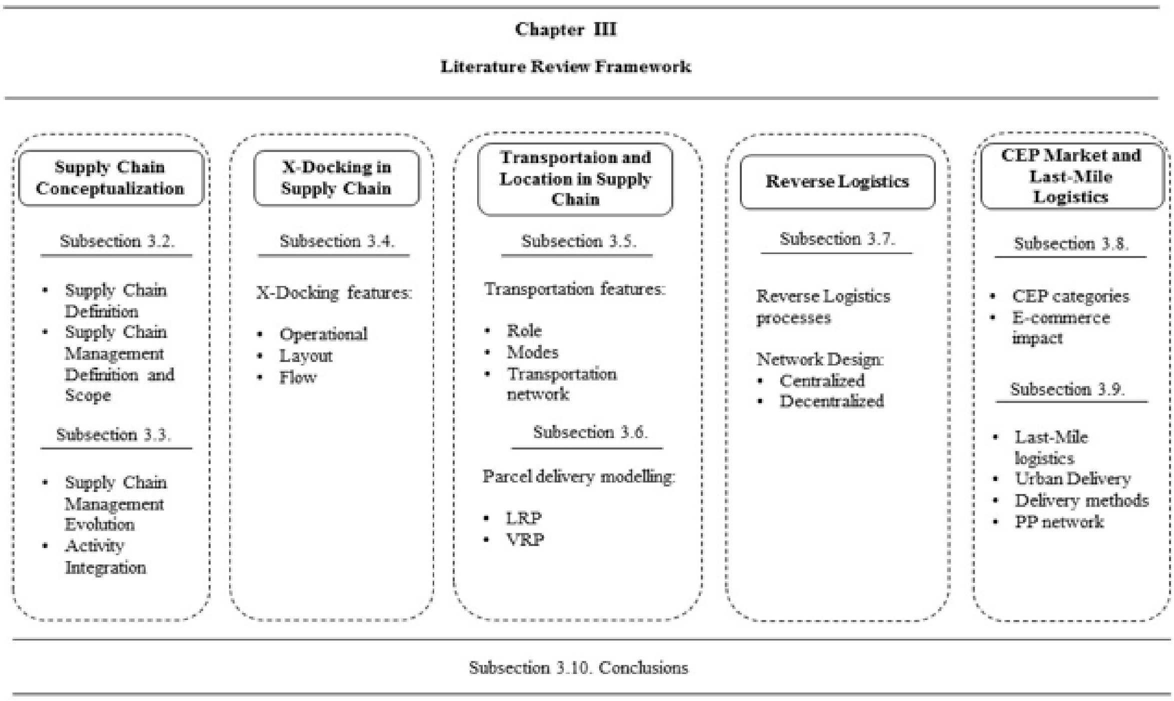

Figure 14- Literature Review Framework. *Own Elaboration*

3.2. Supply Chain Definition

Throughout the years different definitions of supply chain have been presented. Mentzer *et al*. published an article in 2001, where they defined supply chain as the set of three or more entities, which directly take part in the upstream and downstream flow of products, services, finances and information. The authors considered a minimum number of three entities: supplier, organization and customer to define as supply chain. According to Ballou (2006), supply chain is a wide scope of functional activities (i.e. transportation, inventory management) that can be repeated along the network, by which raw materials are transformed in finish products, with added value for the end-customer, and considering an upstream and downstream flow of materials and information. Customer's demand patterns have been evolving rapidly and moreover, request products to be delivered faster, on time, in a global market. This complex demand, combined with rapidly evolving technology, have been leading to a more dynamic market, calling for greater flexibility in supply chain relations. Consequently, over the 1990s, supply chain management (SCM) began risen attention. While there is not much controversy about the definition of supply chain, SCM finds in literature different point of views for its definition. According to the Council of Supply Management Professionals (CSCMP, 2013), SCM aggregates the planning and management of all type of activities involved in sourcing and procurement, conversion, logistics management operations and both interfunctional coordination and interorganizational collaboration. More synthetized, SCM integrates supply and demand management, both within and transversely to companies. After comparing different SCM definitions in literature, Mentzer et al. (2001) defined SCM as the strategic coordination of traditional business units, both within a single company and all the other business functions across the supply chain, with the common purpose of improving the performance of individual companies and the supply chain as a whole. Stock & Boyer (2009) shared the same definition and distinguished different business units including material suppliers, purchasing, production facilities, marketing and sales, logistics, and systems that somehow facilitate the direct and reverse flow of materials, services, information and finances from production to end-customer. For the authors, SCM is a tool to create added value, maximize efficiencies and fulfil customer's requirements.

After extended research on SCM definition, Mentzer et al. (2001) distinguished three categories for SCM classification:

- Management philosophy
- Implementation of a management philosophy
- Set of management processes

Figure 15 illustrates these main features and considerations about the three categories for SCM. From management philosophy point of view, SCM is described as a single integrated entity with strategic intrafirm and interfirm cooperation. In a different way, from an operational perspective focused in a set of management processes, SCM can also be approached under input/output process orientation, with emphasis in customer's requirements. At last, SCM can be analysed from an activity outlook, concerning the implementation of a management philosophy. Instead of centring in the philosophy itself, this approach focusses in the set of activities that allow its implementation. These activities comprehend a broad set of choices, from information and risk sharing, to cooperation and integration of processes.

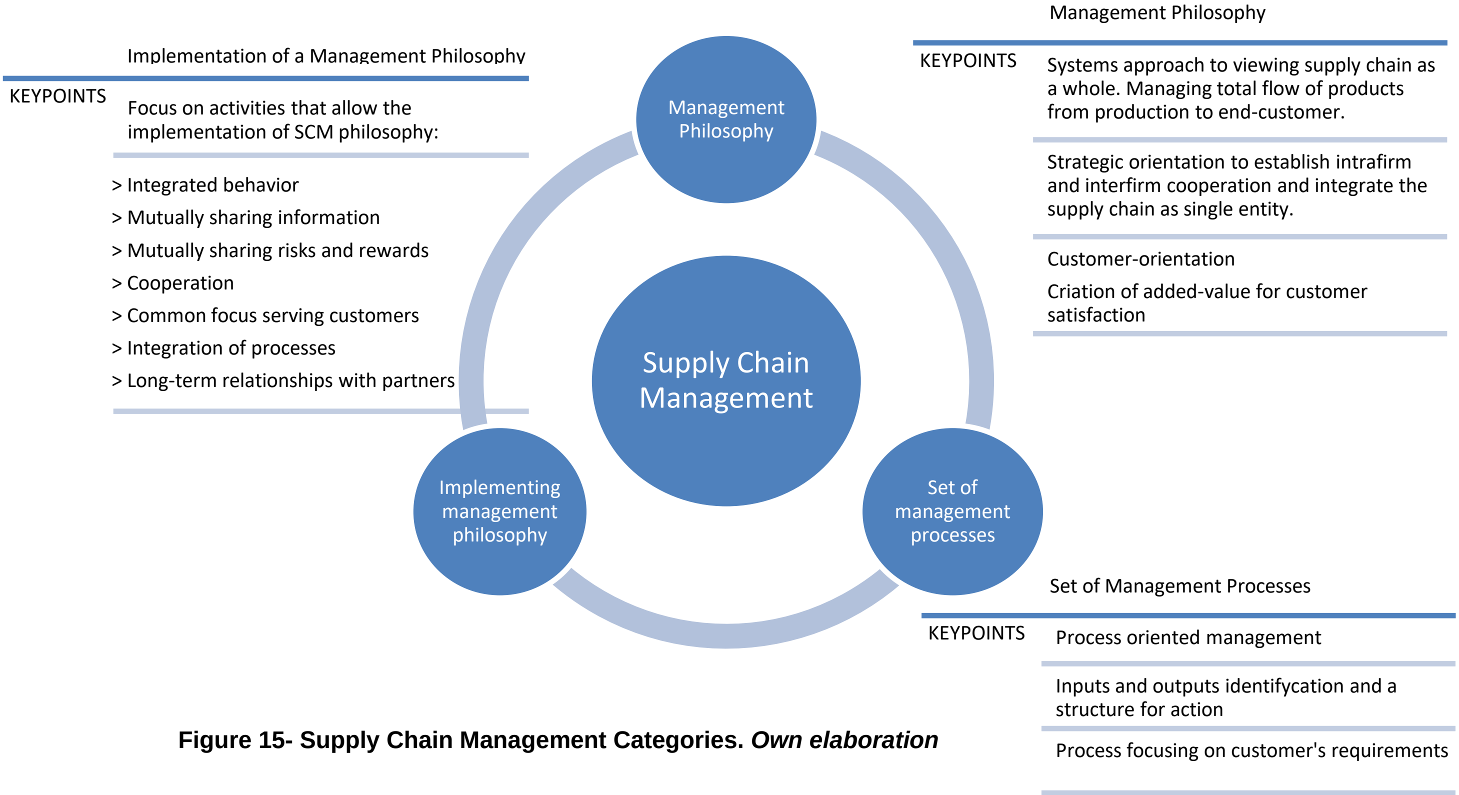

Figure 15- Supply Chain Management Categories. *Own elaboration*

Supply Chain and SCM are fast-paced evolving concepts. Over the years, these ideas have been reshaped and refined, according to company's and customer's evolution. Thus, it is vital to understand these concepts' evolution, as presented in the next section.

3.3. Supply Chain evolution

The genesis of the concept of supply chain can be traced down to the early thoughts of Jules Dupuit, 1844, about coordinated management. However, the concept has been evolving over the years.

In 1950s, Logistics was study under military perspective as the science responsible for searching, maintenance and transportation of materials, people and facilities. Until 1960s, logistics was seen as the sum of fragmented activities. Companies had no deep understanding about cost trade-offs and fragmentation was leading to sub-optimal performance results (Ballou & Gilbert, 2000).

Companies successfully identify fragmentation as an obstacle to optimization and, in the 1960s, started integrating activities to achieve new-optimal solutions. The Council of Logistics Management (CLM), established in 1962, defined logistics as the process for planning, implementing and controlling the efficient and effective flow of goods, services and information from the source to end-customers, regarding customer's requirements (Ballou 2006).

Although the concept of SCM started appearing in literature in the 1980s, it was only described from a theoretical point-of-view in the 1990s (Cooper et al. 1997). With continuous integration of activities, see Figure 16, to achieve competitive advantages, the CSCMP identify the need to define Logistics as a part integrated in the supply chain. In fact, understanding the rising demand for integration, the Council of Logistics Management became CSCMP in 2005, with a broader scope on the entire supply chain.

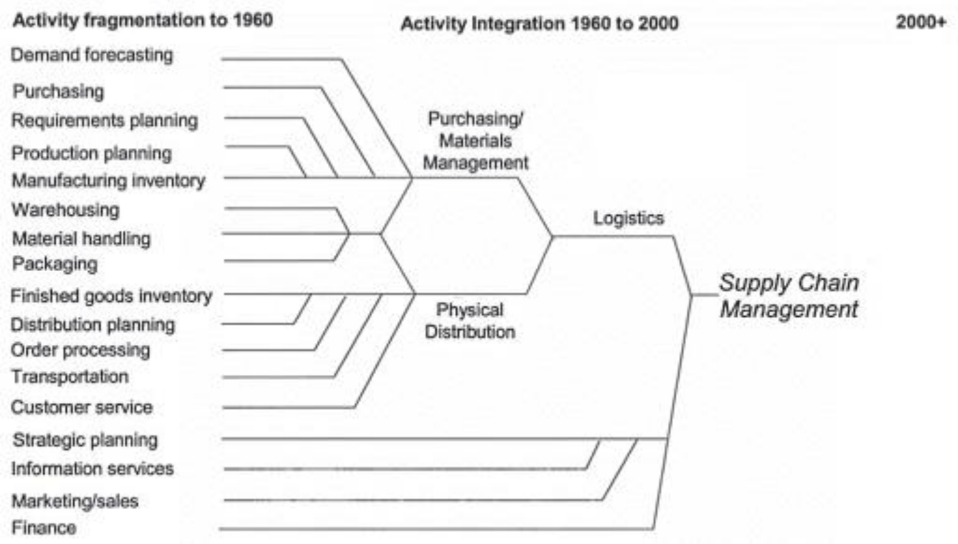

Figure 16- Supply Chain Management Evolution. ***Adapted from Ballou (2006)***

As time moves by, efforts have been made for integration. Thus, SCM can be viewed under three dimensions: activity and process administration, which is integrated under logistics' function, i.e. managing transportation, warehousing, stock; interfunctional coordination refers to building and strengthen relationships with other functional areas within the company, i.e. marketing & sales and finance; interorganizational coordination is related with collaboration and coordination of product flows between different channel members. Ballou (2006), refers that SCM is responsible for product flow managing across multiple enterprises (multi-dimension), while Logistics is responsible for product flow activities within the company.

Despite the fact that SCM has been evolving towards activity integration, the impact of the different activities to the overall costs of the supply chain can be very unlike. That way, warehousing and transportation are key activities, both cost wise and impact in the dynamics of the supply chain. According to Ballou (2004), transportation can account for one to two thirds of all logistics costs. On the other hand, warehousing is also critical, not only in cost perspective, but also because of its impact in the design and dynamics of the supply chain. Following sections will approach these activities with deepen knowledge, exploring the X-docking aspects when treating warehousing and transportation characteristics.

3.4. Supply Chain Warehousing using Cross-docking

Warehouse operation is an important part of the logistics network that, although it does not add value to the product, it is decisive to present the product to end-customer. Production and demand are often far apart, and warehouses are necessary to create a cost-efficient logistics network. Thus, warehouse operation is fundamental from the economical perspective of the supply chain but also because it allows to move the products closer to the customer, improving service level (Crespo de Carvalho, 2012). However, the nature of the product or company's business model, might require a faster and inventory-free strategy, such as cross-docking, the type of operation explored in this work by UPS.

Cross-docking is a logistics strategy based on the transfer of products directly from incoming shipments to outbound distribution without storage in-between (Van Belle et al., 2012). Cross-docking definition under perspective of consolidation is referred by Kinnear (1997) as receiving products from different suppliers for different end-customers and consolidate the shipments based on delivery location. This definition suits better with the purpose of UPS to achieve savings in transportation costs. A successful implementation of cross-docking thought, request for planning and controlling software, as well as good IT support (Yu & Egbelu, 2008), (cross-docking trends report, 2011).

Cross-docking is used according to a lean supply chain management, usually dealing with smaller volumes and increased delivery frequency (Cook, Gibson & MacCurdy, 2005). Thus, when compared to traditional warehouses, cross-docking advantages are related to cost reductions (from warehousing and inventory costs to labour and handling costs), shorter lead times and improved customer service, storage space reduction, faster inventory turnover, reduction of overstock and improved product safety. On the other hand, cross-docking advantages compared with point-to-point deliveries are also related to cost reduction (transportation and labour costs), but also with shipments consolidation, resource utilization improvements (i.e. use of FTL) and better match between shipments and actual demand (Van Belle et al., 2012).

3.4.1. Cross-docking features

The operations involved in cross-docking can be aggregated in categories, referring to operational and layout features. The differences between categories result from distinct industries' specification and demand requirements.

Operational characteristics

Literature has made some distinctions between different types of cross-docking operations. There is pure cross-docking or one-touch cross-docking where products are only touched once to be transferred from inbound transport to outbound vehicle (Van Belle et al., 2012). In addition, there is also two-touch or single-stage cross-docking, where products are staged on the dock before outbound transportation. A more complex operation is multiple-touch or two-stage cross-docking. The first part of the operation is similar to single-stage where products are staged on the dock but then products are consolidated and reorganized close to the outbound doors.

Boysen and Fliedner (2010) added *service mode* of a cross-dock has a variable that can influence operation results. Service mode represents the degree of freedom when assigning inbound or outbound vehicles to a specific dock door. Thus, the authors define *exclusive mode* when a dock door is exclusively assigned to inbound or outbound logistics. The second service mode is *mixed mode*, in which inbound and outbound operations can take place at all doors. Whenever is necessary to combine both service modes, cross-docks can operate a *combination mode*, allowing some dock doors to be operated in exclusive mode, while others are operated in mixed mode. In addition to service mode, the authors define *pre-emption* as another decision that can impact operability. Pre-emption decision implies that a specific loading/unloading truck operation can be interrupted and postponed, so that preference is given to a different truck.

Cross-dock layout and flow characteristics

According to Belle, Valckenaers, & Cattrysse (2012), cross-dock infrastructure's features comprehend the physical layout (i.e. shape I, L, U, T, H), number of dock doors and type of internal transportation. The type of transportation used inside a cross-dock is dependent on the type of products moved. For standard pelletized products, transportation should be made manually, using forklifts. In opposition, for small parcel carriers like UPS, small automated conveyor belts can be used to improve efficiency and reduce operational costs (UPS, 2016a).

The flow of goods inside a cross-docking process can be very different depending on the nature of products and customers. Although, flow of goods is related to arrival patterns of inbound logistics. Arrival times can be *concentrated* in a specific time-window or be *scattered* during the day. The type of arrival pattern will have implications in cross-dock's congestions and resources' assignments. Furthermore, departure time of transports can be restricted or not. Both inbound and outbound transportation can be restricted, whether if there are other transports waiting for the cargo or to make sure products are delivered on time, respectively. UPS Portugal has restriction time for inbound air-cargo and outbound truck deliveries. Adding to arrival and departure patterns, also product interchangeability can influence the flow of goods. Interchangeability refers to products that are not previously designated to a specific destination or truck. These products usually require added-value activities, such as labelling. Whenever temporary storage is necessary in cross-docking operation, flow of goods is affected.

For this project, the flow of goods processed in UPS consolidation points is basically determined by arrival and departure patterns, since no interchangeability and temporary operations take place. All products destination is previously known before products arrive at cross-dock. In addition, no temporary storage is used, once UPS operates pure cross-docking. Parcels do not touch the floor. From inbound trucks, goods are transported via conveyor belts to outbound LTL.

3.5. Transportation

As previously discussed, supply chains are evolving towards activities' integration. Besides, globalization is a crucial external factor that have been shaping organizations and the way they behave. More and more, customers' empowerment and information expand the boundaries of potential markets, and companies must adapt their supply chain to meet customer's requirements. Thus, transportation is decisive not only to bridge supply and demand gap, but also in a broader way, for people mobility and economic livelihood. Although transportation adds no value to the product, it provides place and time utility, by moving goods efficiently and effectively to the right place, at the right time (Coyle et al., 2011).

3.5.1. Transportation modes and features

The decision about the transportation mode is critical for transport management within the supply chain. Transportation mode's decision should be made under the trade-off between transportation costs and customer's service level. The basic modes of transportation include airlines, motor carriers, railroads, water carriers and pipelines. To evaluate the best transport mode for a company, it is important to compare the following fundamental characteristics of each transport: price; transit time variability; flexibility; capacity; frequency; losses and damage (Crespo de Carvalho, 2010):

Price

The price of a transportation service widely varies depending on the mode of transportation chosen. In addition to costs related to the movement of goods, other costs like product handling, loading and unloading operations, insurances and costs associated with transit inventory are also reflected in the transport price.

Transit time and variability

The average transit time associated with a mode of transport is related with the average time to move the goods from origin to destination point. To evaluate the transit time of a specific mode that is unable to make all the transportation is often necessary to deal with intermodal transportation, combining more than one type of transport. Variability translates the exposure which a certain mode of transport faces from external or operational forces that affect transportation performance. Transit time has significant impact in inventory level and consequently in inventory costs. Thus, a trade-off between speed and stock level must be evaluated to optimize the supply chain’s overall costs and still maintain customer’s service level.

Flexibility

Flexibility is the variable that represents the ability to connect to different points in the supply network. It is a critical variable for the performance of different transportation modes and takes particular importance in the parcel industry, since it requires maximum flexibility for point-to-point delivery.

Capacity

Capacity refers to the ability to accommodate a certain product and is influenced by the physical properties of the products, i.e. size, weight, density.

Frequency

Frequency is a performance variable that indicates the number of times a certain transportation connection is made. It is also a decisive indicator for parcel industry, since most of the companies operating in this market rely on just-in-time models with no inventory and high transportation frequency (intraday). A high transportation frequency allows better responsiveness to customers, but it is also more expensive, due to more travelling. Lower frequency allows products’ consolidation and therefore, economies of scale and cost savings. Once again, a trade-off between shipments’ time and stock level must be assessed.

Losses and damage

All transportation operations imply damage or loss risks. Although it is not clear which transportation modes are safer, airlines and pipelines present better average performances. In addition, there is also a correlation between transhipment of goods in intermodal activities and increasing risk for damage and losses.

3.5.2. Transportation Routing

The implementation of transportation networks is complex, and it is usually assisted with integrated mathematical models for optimization. Operational research investigations have been helpful in finding solutions for transportation problems. According to Crespo de Carvalho (2012), transportation routing problems can be divided in categories:

- **Shortest Path Problem**- Given two different points of the network, defined as origin(O) and Destination(D), the mathematical model must find the combination of nodes and arches that minimizes total cost/distance.
- **Transportation Problem**- The analysis is made for direct shipment between multiple O and D. A known extension of transportation problem is the "Milk-Run", that allows transhipment between origins points to fulfil a specific destination. By using transhipment between origins, "Milk-Run" networks reduce the number of connections between Os and Ds. This type of networks is common for just-in-time distribution, allowing overall stock reduction, but increasing coordination complexity. Furthermore, another extension of transportation problems is also studied when shipments from Os and Ds are consolidated in intermediate depots, for final delivery. This type of study is associated with cross-docking operations.
- **Traveling Salesman Problem**- When origin and destination nodes are coincident, and all nodes must be visited only once. The optimization model chooses the best flow, to minimize overall costs.
- **Vehicle Routing Problem**- The analysis of the routes each vehicle must perform to visit all customers that have been assigned, at minimum cost. The origin point is common for all vehicles, but they have capacity constraints. Vehicle routing problem is used by UPS to optimize vehicle routing over a central depot. Thus, further investigation is made under this topic.

3.6. Modelling Parcel Delivery System

Modelling a parcel delivery system requires both strategic decisions on hub location, and operational research for Vehicle Routing Problem (VRP) (Bahrami, *et al.*, 2016). An integrated model with both variables is necessary to cope with complex situations and achieve reasonable solutions.

3.6.1. Location Routing Problems

The integrated approach for location-routing problems (LRP) was first introduced by Laporte (1988), with a model-solving for facility location and distribution problem. LRP modelling tends to solve a three-layer problem: Location and number of facilities/hubs, node's allocation to facilities/hubs and routing design between nodes and facilities (Lopes *et al*., 2013). Although LRP research is quite recent, a lot of investigation can be found in literature (see LRP review by Min *et al*. (1998), Nagy and Salhi (2007), and Lopes *et al*. (2013)). The taxonomy and classification of LRP is extensive because each specific problem´s structure tackles a real-life scenario. Figure 17 presents some configurations for LRP modelling, from a single location-allocation problem to a more complex Multi-level LRP.

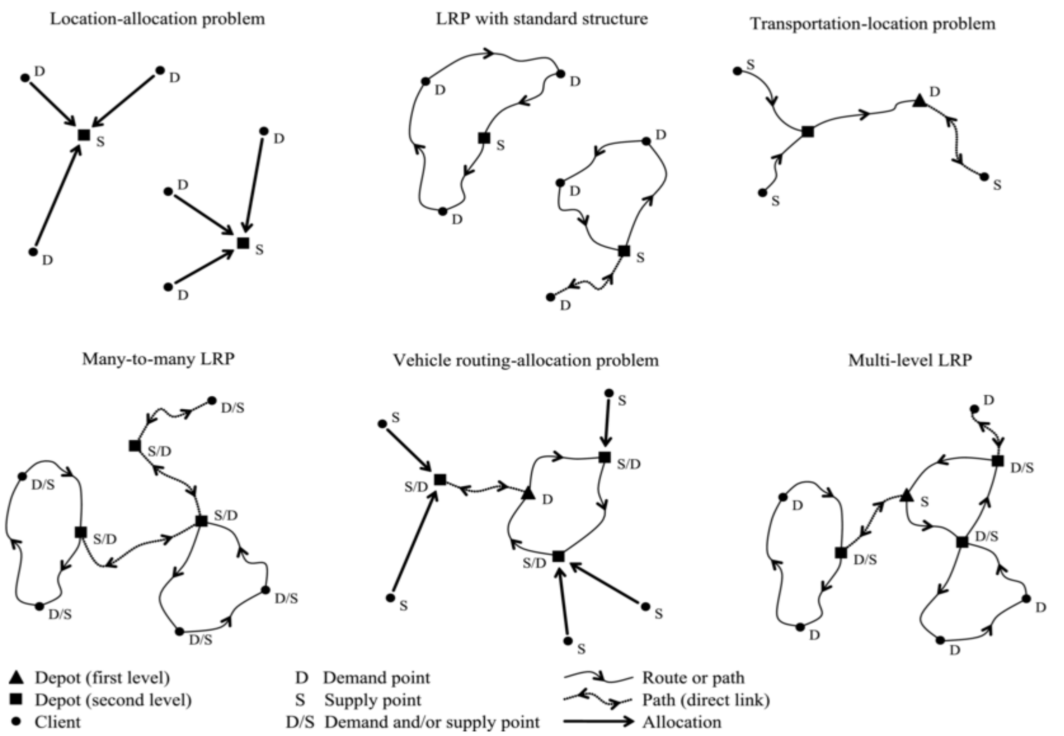

Figure 17- Examples of graphical representation of Location-Routing problems. *Adapted from Lopes et al. (2013)*

On the application of the published model to the parcel delivering problem few works have been identified. Wasner and Zäpfel (2004) considered a mid-sized Austrian parcel delivery company and developed a generalized hub location and vehicle routing for network design. The authors considered that vehicles perform both pickups and deliveries, and customers or postal zones are allocated to service areas of a certain depot. In addition, the research focused on routing client-depot, hub-depot and hub-hub. After formulation, the authors used hierarchal heuristics algorithm to solve the problem. Čupić and Teodorović (2014) developed a multi-objective approach to the parcel express delivery problem in Serbia. The authors focused in profit and service level maximization and used genetic algorithm to implement their research in a distribution network with 16 nodes. Bahrami *et al*. (2016) studied how to model a door-to-door parcel delivery network in Iran. The authors integrated both hub location and vehicle routing and used simulated annealing algorithm to achieve reasonable solution.

After concept review about LRP problems and building the bridge with the present case study, it is now relevant to understand the role of Reverse Logistics, within parcel's supply chain network. In this sense, it is important to realize what implications may have when parcels must go through reverse flow.

3.7. Reverse Logistics

Reverse logistics is a specialized segment of logistics concerned with management and movement of products and resources, post-sale and after delivery to customer (CSCMP, 2013). From cost perspective, reverse logistics can be defined as the set of processes of receiving returned products, either to recapture value or for disposal (Greve & Davis, 2012). Reverse logistics is often seen as a cost of doing business and is frequently undermanaged. However, according to an Aberdeen Group study (2010), the average manufacturer will spend 9% to 15% of total revenues in returns. Reverse logistics presents specific challenges distinct from forward-moved supply chains. Some companies try to manage reverse logistics through forward logistics channels, but often find increasing operational complexity and costs. Forcing reverse logistics through forward channels can be compared as analogy to the cardiovascular system, as if forcing the blood to move both ways in the same artery, instead of having two different and specialized channels for different types of blood (de/oxygenated) (Deloitte, 2014). Reverse logistics costs are less than 4% of total supply chain costs for most companies. Nevertheless, there are several key areas that can be affected by reverse logistics activities (Greve &Davis, 2012; Deloitte, 2014):

- **Customer loyalty**. Customer experience and brand perception are processes that begin before the purchase and are extended afterwards, trough returns and repairs. A customer that experiences a good return service is more likely to return to the store and remain loyal to the brand, than otherwise.
- **Returns-to-Revenue**. Companies that operate an efficient reverse logistics network, are more likely to save value on returned products. Either by reselling to parts or refurbishing or reselling for secondary discount markets, returned products hold revenue opportunities. Maximizing recovery rates is important to operate an efficient reverse logistics channel.
- **Regulatory Compliance**. Although returned products mean revenue losses and often result in profit margin cutting, it is also true that efficient management of reverse logistics can help companies to avoid penalties from regulatory agencies.
- **Disposal Benefits**. Companies operating reverse logistics should make efficient assessments on what type of products are returned and what should be the action. In addition, companies can benefit from proper product disposal, either by decreasing inventory holding costs, or by minimizing taxes and insurances.

According to Greve and Davis (2012), usually less than 20% of products processed through reverse logistics channel are defective returns. It means that products can be returned from different causes, each one with unique features. Figure 18 represents the reverse logistics pipeline, with different categories for products return on the left, reverse logistics activities in the middle, and product's destination on the right.

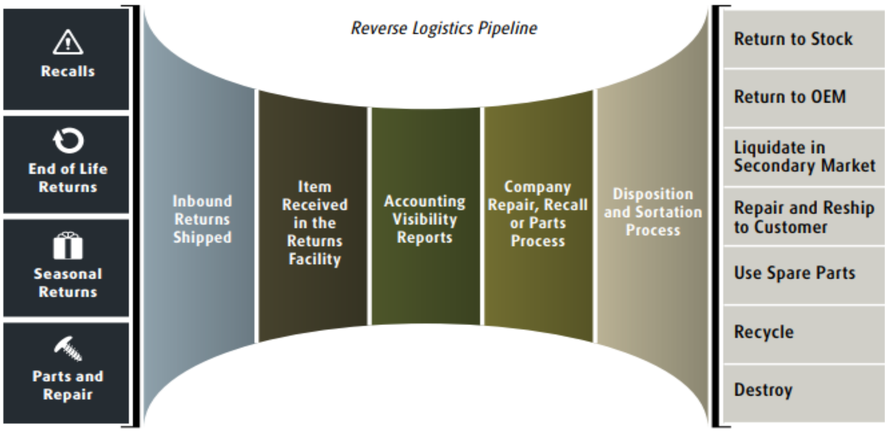

Figure 18- Reverse Logistics Categories and processes. ***Adapted from: Greve & Davis (2012)***

In today's world, manufactures must be prepared to **recall** their products, forced by regulatory agencies. These recalls can be originated by defective packaging or warning labelling to potential hazards, but also by faulty equipment or construction. In the electronics' industry, recalls are common, due to problems with batteries, i.e. Samsung Galaxy Note 7 recall because of batterie explosions. Defective products can present high liabilities for companies, either from fines and penalties from regulatory agencies, but also from lawsuits and consequent damage to brand's value. **End of line returns** is associated with the pull order of outdated products, to create market space for new models, i.e. apple pulls older models of iPhone and only sells new versions. Besides, companies can have better control of obsolete products, and make sure that new models are being sold. End of life programs help companies to maintain the brand image, and is important for products with fast life cycle, such as electronics. **Seasonal returns** refer to companies driven by seasonal demand. Usually, after a particular season, unsold items are returned to manufacturer or distributor, either to be sold on secondary markets or to be repackaged and resold in primary market, within days. The category of **parts and repair** allows companies that operate efficient reverse logistics networks, to benefit from returned unused, overstocked or defective parts. These parts returned present benefits to both manufactures, by reducing inventory in parts, and companies with significant field repair, by reducing investment in parts. Reverse Logistics' pipeline holds a broad number of processes, which intend to either recapture product's value or protect the company against any kind of problems, arising from default products. However, the decision about implementation of Reverse Logistics system, must consider the network design and the location of respective activities.

3.7.1. Reverse Logistics Network Design

Companies implementing reverse logistics networks need to decide between centralized and decentralized network design, according to customer's requirements and geographic location. Besides, it is also important to evaluate other factors, such as product lifecycle, product value and cost, and also volume and geographic distribution of returned goods (Deloitte, 2014). Figure 19 illustrates the differences between centralized and decentralized reverse logistics networks. While centralized networks collect returned products to a sortation hub, where products are aggregated and sent to a specific destination, decentralized or distributed models use direct shipment to the specific working units.

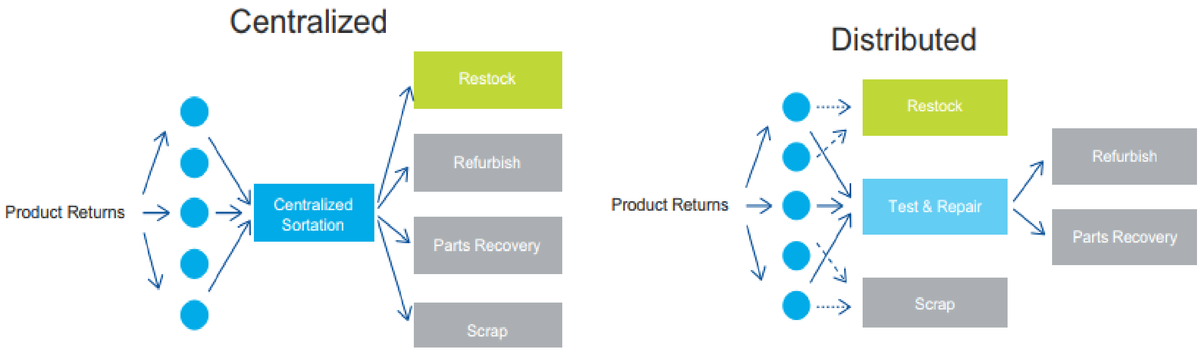

Figure 19- Reverse Logistics network design. Adapted from *Deloitte (2014)*

The second decision when designing a reverse logistics network, is to choose between a close loop, where a network is responsible for the entire reverse logistics, including reuse of recovered materials, and open loop, where networks are only responsible for collection and sorting activities.

To operate a successful and efficient reverse logistics network, robust IT tools and personal skills are required. Often, companies do not have this expertise and choose to outsource to third-party logistics (3PL) providers. When outsourcing reverse logistics activities, companies need to assess whether to outsource the entire reverse network, or specific activities, i.e. transportation or sorting. A successful management of reverse logistics is related with how managers want to address the reverse flow of materials. Thus, companies can build dedicated reverse logistics networks to deal with the specifications of these channels, and turn returned goods in competitive advantages (Deloitte, 2014).

After a broader outlook to the mechanics of SCM and a drilldown to the relevant activities of Warehousing, Transportation and Reverse Logistics, it is significant for the project's scope to zoom in on Courier, Express and Parcel industry, so to understand the specifics of the market.

3.8. Courier, Express & Parcel Industry (CEP)

The European Courier, Express and Parcel sector (CEP) is a dynamic sector with deep connection to globalization. The CEP sector is a distinct activity from the postal service and has evolved over the last 20 years from general LTL (Ducret, 2014). CEP aggregates three segments with different delivery solutions. The **parcel** sector is limited in size and weight, with a maximum weight of 31.5 Kg. Parcels do not have a guaranteed delivery time and delivery process is unaccompanied. The transportation process for parcel delivery is standardized and usually via transhipment hubs. **Express** and **Courier** services are more customized and thus, more expensive. Both services have no restriction in weight and size and delivery process is permanently accompanied. Courier is handled in person or tracked electronically, while express is usually just tracked by electronic means. This permanent follow-up allows customers to know at every step of delivery process where their packages are. Courier offers same-day delivery options, whereas Express services offer specific time windows for delivery. Courier segment differentiates its delivery process by using point-to-point direct routing. In simple words couriers deliver products as fast as possible from package location to end-customer without transhipment (Esser and Kurt, 2017). Figure 20 represents the main features of each category within the CEP industry, regarding weight and size, accompaniment, speed and transportation.

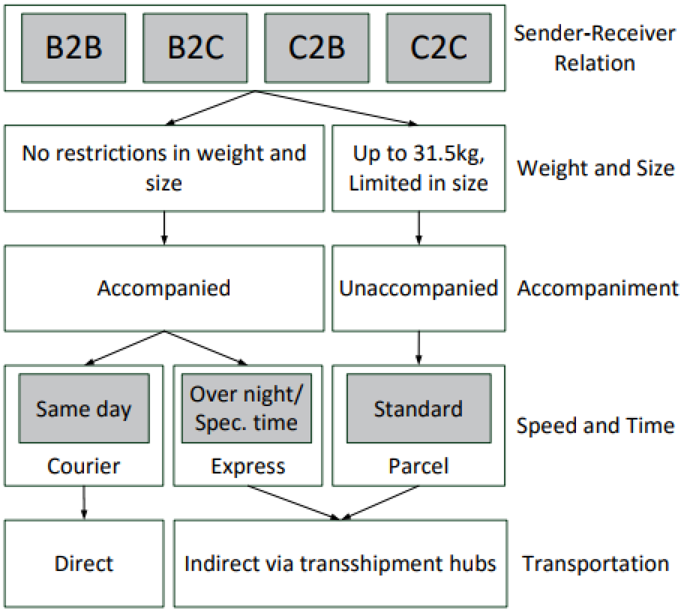

Figure 20- Features' specifications for CEP classes. ***Adapted from Esser & Kurt (2017)***

Ducret (2014) has identified three categories of players involved in the European CEP sector: The Heirs, Other Players and New Players. The **heirs** refer to the traditional players in CEP sector, including Post Office, Express providers, the mail-order sector and the couriers. **Other Players** aggregates a more heterogeneous group of companies, originally focused on upstream activities of the supply chain. These players were used to deliver heavy goods and palletized products but were forced to evolve thanks to the rise of the e-commerce, with special impact in B2C segment. Thus, these companies developed a broader portfolio of services and know include urban B2C parcel services. Furthermore, Other Players also include sub-contractors, which have become a common trend for urban last-mile deliveries, i.e. sub-contractors accounts for 50% of UPS activity in Paris and 100% of UPS activity in Portugal. **New Players** refers to companies specialized in B2C parcel delivery. This group includes new innovative companies but also big players from the e-retailer, such as Amazon or eBay. New Players segment is characterized by start-up spirit and innovation.

3.8.1. The Impact of e-commerce on CEP market

The shopping habits in Europe have undergone significant change over the last decade, with more consumers buying their products on-line. The boom of e-commerce turned the CEP market from pure B2B oriented to a mixed B2B and B2C. B2C segment has been outgrowing B2B, so companies have started to address questions related to end-customer requirements. (DHL, 2017; UPS, 2017; Accenture, 2015) It is important to mention that CEP market is the backbone for the rise of E-commerce. These companies offering CEP services face a constant trade-off between last-mile cost optimization and improving customers' requirements. Constant technology innovation allows CEP players to differentiate their portfolio of services and helps customers to keep tracking of their packages. The end-consumer is becoming more and more demanding, so CEP companies need to use innovation to present solutions for the When and Where customers want their packages delivered (Esser and Kurt, 2017). Any slight discrepancy between customer's expectations and company's services can easily lead to parcel's return. Customer's empowerment through e-commerce is a key driver to the increase of Reverse Logistics operations, within the CEP industry.

3.8.2. Drivers of change in the European CEP market

Retail revolution

Over the last decade consumer habits have been changing leading to the rise of e-commerce. In the European Union (28 countries), in 2016, 45% of people claim to have purchased on-line for personal use during the last 3 months prior to the survey, with an increment of 22% since 2007. Between the European countries there is a group of on-line mature markets, such as the UK 78%, Denmark 71% and Germany 64%. In addition, there is also an intermediate group with France 52%, Austria and Finland 48%. The group of developing markets aggregates Spain 35%, Poland 31% and Portugal 23% (Eurostat, 2017). E-commerce is responsible for a change in consumer habits and consequently, parcel delivery companies' requirements. This new consumer is more dynamic and demanding, which requires better service in respect to reliability, delivery speed, proximity and flexibility (Ducret, 2014). B2C e-commerce segment has been experiencing double-digit annual growth rates for the past 5 years and is outgrowing B2B segment. In Germany, for the first time in 2016, the volume of B2C segment overcame B2B. New customers' habits are leading to increasing just-in-time and small parcel deliveries in urban areas. (Esser and Kurt, 2017). Although B2C has been outgrowing B2B segment, the largest turnover is made in B2B market. Figure 21 illustrates the compound annual growth rate (CAGR) between 2013 and 2020(f) for North America, Western Europe and Asia Pacific. B2B accounted for roughly two-thirds of CEP turnover because it has higher profitability and preference for express dominance and thus, lower price sensitivity (Accenture, 2015). However, it is expected that B2C segment slowly starts to increase its market share over the next years.

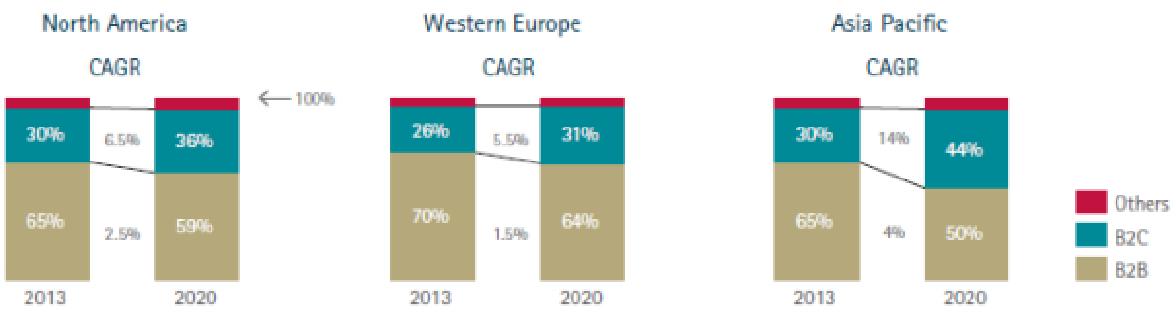

Figure 21- CEP market share- B2B vs. B2C (USD billion %, 2013-2020f). ***Adapted from Accenture (2015***

Growing resemblance and complexity between B2B and B2C deliveries

In previous years there was a clear distinction between services specialized for business and those for the individual consumer. The CEP sector has been evolving and moreover, B2C delivery requirements are converging with traditional B2B standards. Individual consumers have become more demanding when presenting an on-line order, regarding to speed, service quality, reliability and convenience (Savy & Burnham, 2013). Increasing B2C requirements led CEP players to keep differentiating their services and widen their portfolio. However, the last-mile for a B2C delivery is much more complex than B2B, especially when it is a home-delivery that requires a signature from the recipient. According to Gevaers, Van de Voorde & Vanelslander (2009&2011), the nature of the last-mile for a B2C delivery is based on: Level of consumer service, security and type of delivery, market density and penetration, fleet and transportation and finally, the trade-off between a fast delivery and environmental impacts. To mitigate the B2C last-mile costs impact, CEP companies have been developing alternatives to home-delivery, such as UPS Access point.

Local authorities' concern over urban logistics

According to the commission staff working document (2013), 73% of Europeans are already living in cities and cities are responsible for 85% of Europe's GDP. This growing urbanization combined with the rise of e-commerce and home-delivery is putting pressure in urban logistics. The increasing demand for parcel deliveries within the cities is raising awareness of local authorities because of congestions and pollution related problems. Thus, local authorities are forcing CEP players to change their operations, whether by congestion charges or low emission zones with specific time windows for parcel operations (Ducret, 2014).

The European CEP market is being forced to evolve because of the pressure of previous driving forces. Thus, CEP companies have been adjusting the last leg of their logistics operation, in order to improve efficiency and customer service.

3.9. Last-Mile Logistics for Urban Delivery

According to the last study performed by the International Post Corporation (IPC, 2016), 76% of consumers prefer home delivery service and 72% of respondents refer to have used the post for final delivery. On the other hand, 94% of customers mention to have used the post for parcel returns, strengthen the idea that logistics providers often try to avoid the complex reverse logistics processes. In Portugal, around half of customers are buying from China (32%) and Spain (20%), while countries like the U.K., U.S. and France account for 15%,8%,7%, respectively. Although Post companies take such a huge role in parcel distribution, through their wide network of assets and infrastructures, some companies have struggled to adjust their business model from light documents to parcels. Home delivery can be performed by traditional postal mail companies, courier services or crowd-shippers (see Figure 22). As an alternative to home delivery, automated parcel stations (APS) equipped with parcel lockers and pick-up points (PP) are fast-growing solutions. Although APS solutions demand large investment costs it is a good alternative for last-mile delivery, since it reduces missed deliveries and allows off-hour operation (Augereau & Dablanc, 2008). The UK, France and Germany account for 71% of European e-commerce market and APS and PP solutions already account for 10 to 20% of shipment deliveries (Morganti, Dablanc, & Fortin, 2014). The third method used for last-mile delivery is crowd-shipping, which consists in using a crowdsourcing network to perform last-mile deliveries. Although this method is considered very flexible and efficient to cope with demand fluctuations and allows to have a better resource leverage (i.e. parcel delivery and taxi/Uber services), McKinsey (2016) indicates that crowd-shipping will only have a minor role in the future of last-mile. The main drawbacks with crowd-shipping are quality and reliability issues, but also legal requirements that often limit the action of this delivery method.

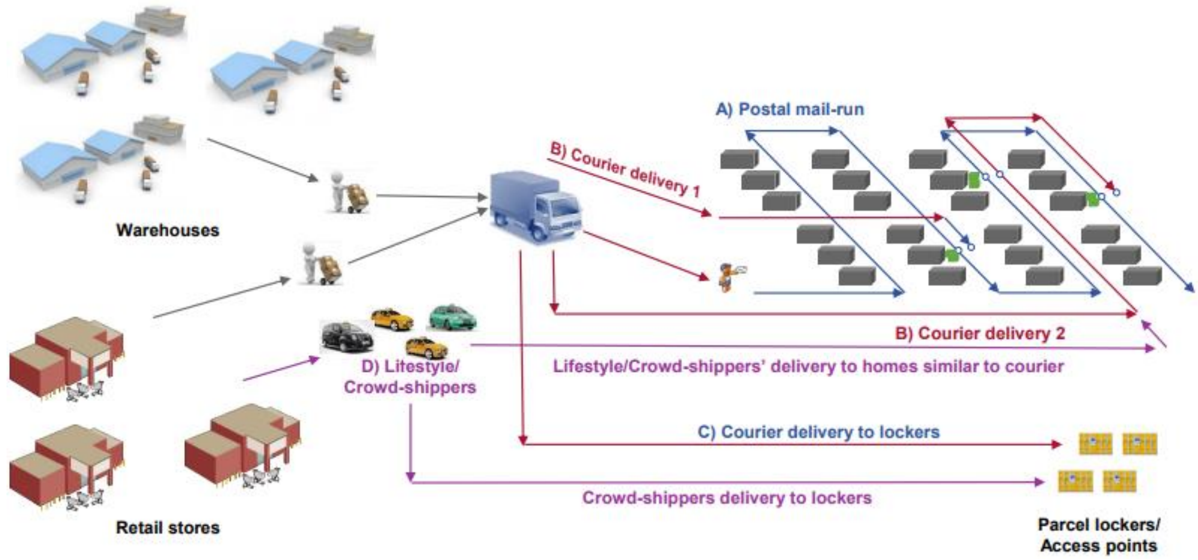

Figure 22- Last-Mile Logistics approaches for urban delivery. ***Adapted from Accenture (2015)***

The rise of e-commerce has defined home delivery as the new premium service for package delivery. According to a study conducted by McKinsey (2016) in three mature package delivery markets, such as the U.S., Germany and China, more than 50 % of consumers consider price as the most important decision variable. In addition, last-mile delivery process often accounts for 50 % of total parcel delivery cost. Thus, PP networks have good potential to keep growing (Green Paper EU, 2012) , since it allows significant efficiency improvements and consequently cost reduction. This efficiency improvements can translate more competitive prices for customers. In the same research, McKinsey claims that 70 % of consumers (X2C) prefer the cheapest option of home delivery and new technology developments for home delivery, such as drones will have an important role in the future of parcel delivery. Also, a growing concern on how to handle reverse logistics characterizes this new context.

Table 1 presents a SWOT analysis for the pick-up points (PP) network solution for parcel delivery. The SWOT analysis rests on the idea that PP network enhances flexibility and allows cost optimization, through mileage and reverse logistics decrements. However, the main down side lies in the fact that increased flexibility demand for customer to perform initial/last mile. From threats perspective, growing e-commerce may present challenges to PP density and consequently, increasing mileage. On the other hand, new and more effective alternatives to home deliver transportation may be obstacles to PP network development. The opportunities exhibited by PP network might reflect in final price reduction, but also in efficiency improvements to parcel's operators.

Table 1- SWOT analysis for PP network. ***Adapted from Iwan et al. (2016) and Morganti et al. (2014)***

Strengths	Weaknesses
• Customers can access their packages during off-hours operation time and are informed of deliveries via SMS or e-mail • Reduction of transportation mileage • Reduction of emissions, noise and energy consumption • Low delivery costs • Reducing Reverse Logistics operations	• The last-mile or the initial-mile must be made by the costumer • Complex IT system to keep package's tracking and run algorithms for constant flow optimization
Opportunities	**Threats**
• Efficiency gains for logistics providers • Price reduction for end-consumer	• Growing e-commerce can lead to a denser PP network, thereby increasing mileage. • Local business reluctance to share store space • New technologies for home delivery: Drones

3.10. Chapter Conclusions

In order to contextualize the case study within a theoretical perspective and search for reasonable solutions, a literature review was conducted in this chapter. Therefore, research in topics such as supply chain management, X-docking systems and modelling location and transportation problems was performed. In addition, current state of the art concerning CEP market and reverse logistics was also analysed to allow better understanding of the concepts. Furthermore, literature allows to understand that moreover Operational Research has been growing as a side-tool for modelling and solving location-routing problems. Although existing literature is abundant in LRP, research about specific last-mile delivery for parcel's industry is rare and represents an opportunity for further analysis. Considering all state of the art it is possible to reach some conclusions concerning UPS Portugal. The company manages a fully integrated supply chain, rather than being just a logistics operator, as commonly described. UPS Portugal aggregates the activities under the scope of Logistics and integrates them with strategic planning, information system and marketing and sales functions. Regarding the supply chain under consideration, it can be determined that it uses pure cross-docking, with a combinatorial mode with some doors exclusively allocated to inbound operations and others allocated to both inbound and outbound. It is also clear that there is a pre-emption decision to prioritize air-cargo (expresso) over truck load (standard).

At last, having under consideration the problem presented for the location of Access Points, it is understandable that Access Point network will have an impact in Reverse Logistics for unattended deliveries, since products will be delivered at Access Point level, instead of re-entering the distribution network. The research displayed in the previous chapters intends to hold the foundations for the development of a LRP model, applied to UPS Portugal last-mile delivery network. The LRP model will be focused mainly in the location decisions, since routing optimization is outsourced by UPS to transportation companies.

4. Problem Data Analysis

After the problem description performed in chapter 2, and literature review development, all premises come together for the deployment of a solution for the problem under analysis. Thereby, this chapter mainly focuses on the optimization formulation that seeks the best UPS Access Points location, for each Zip Code in a restricted area around Lisbon. First, a detailed problem statement is presented, followed by clarification on data collection, data treatment and ultimately, the optimization formulation is presented.

Before addressing the optimization formulation, it becomes imperative to recall the problem. For that matter, the following subsection will focus on a more detailed problem statement.

The original problem arises from a conjugation of structural market changes namely once, a market focused in B2B segment changed to a more and more B2C delivery business. For that, e-commerce boom has contributed significantly.

Growing along the B2C segment is UPS residential deliveries' operation. From 2015 to 2017 residential stops rate has been growing around 3% to 4%, gaining ground to business stops. The constant increase in residential deliveries raises specific operational challenges to UPS's Portuguese structure, namely the rise of unattended home deliveries. As UPS Portugal logistics network is built around a compensatory subcontracted model, guided by the number of packages and number of stops, performed for delivery and pickup services, unattended home deliveries represent extra costs, since another delivery run must be performed meaning another stop and hence, extra compensation fees. In addition, whenever there are unattended home deliveries, packages are reconducted back to UPS logistics hub and need to be reprocessed for further delivery operations.

This current process denotes operational inefficiencies and consequent increasing costs demanding for a change in UPS's reverse logistics network. As portrayed in Figure 23, current residential delivery process operates in the sense that whenever there are unattended home deliveries, packages return to the hub for a next day delivery. Thus, there is at least one more stop to deliver the same product. The alternative for unattended residential deliveries is to leave the goods at the closest UPS Access Point (UAP). Although it also accounts for one extra stop, there is a special compensation fee, which fluctuates between 30% to 60% less, considering the Spanish compensation fees for stops at UAP.

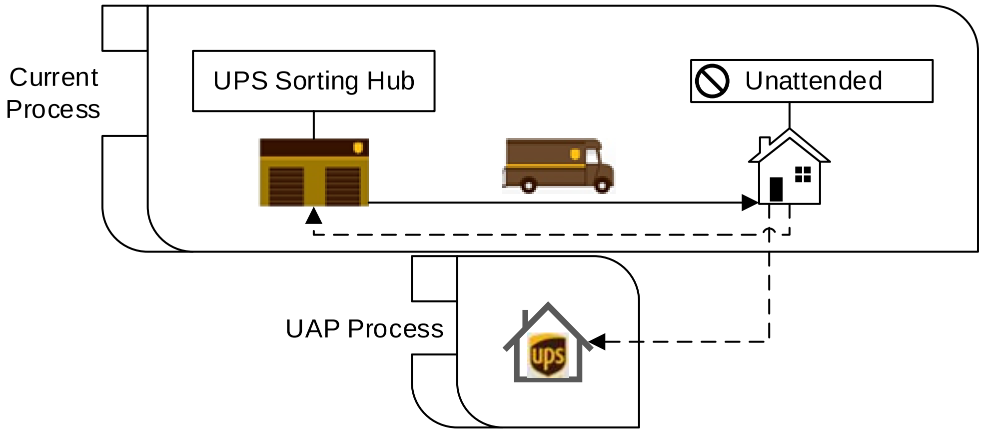

Figure 23- UPS Access Point distribution process. Source: ***Own elaboration***

Another aspect that UPS Portugal intends to explore is that customers can return their packages at UAPs, which allows daily package consolidation. Thereby, only one stop at the end of the shift can collect all the packages, that otherwise would most likely represent one stop per package.

Considering current changes in UPS logistics model, in order to face increasing e-commerce demand, this thesis aims to assess project's feasibility, comparing UPS current logistics solution, against UPS Access Point solution. To do so, a customized optimization formulation is built to run this comparison for each Zip code under evaluation and present the number of potential UAP locations. Afterwards, for all Zip codes where UAP solution would bring economic benefits, a more detailed analysis is performed to access the number of UAP locations, in order to meet UPS requirements, regarding population covering and UAP working hours. This evaluation is performed in the next sections, but before the problem data is treated.

4.1. Data Processing

Current section clarifies on data collection procedures, as well as a description of the data treatment necessary to run the optimization. Data processing is a very time-consuming activity, vital to create a solid representation of the real problem. On that basis, data collection, Big data simplification and necessary assumptions are meticulously justified. To achieve a consistent optimization, it is necessary to breakdown this data processing in two ground stages, such as data collection, where all relevant information is gathered and preselected, and data treatment, which intends to give meaning to raw data. After these two activities, a forecast process takes place, in order to develop future data that will input the cost optimization formulation. Figure 24 portrays data processing methodology, with all relevant activities.

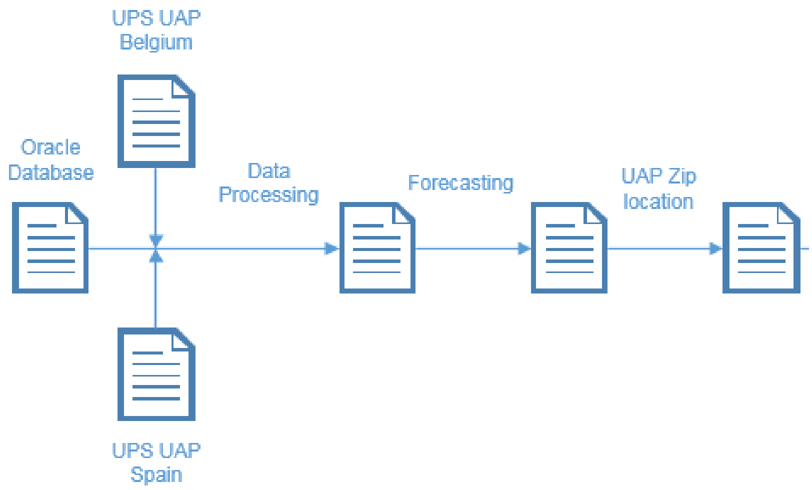

Figure 24- Data source and processing methodology. Source: *Own elaboration*

4.1.1. Data Collection

Data collection took place mainly at UPS Lisbon Hub, at the operation department. Numerous visits to UPS facility contributed to the gathering of Big Data, related to UPS logistics business model. These visits were relevant to collect all data that will give input to the optimization model, namely the number of failed home delivery attempts performed between 2015 and 2017, but also the details about the costs associated with subcontracted outside service providers (OSP), here described as LI1, LI2 and LI3.Furthermore, precise data related to UPS Access Point (UAP) operation, such as UAP store fees and operation costs, were achieved through UPS Spain, where UAP are already operating and also with cooperation with UPS Belgium, which leads the implementation of UAP in Europe. Frequent appointments at UPS Lisbon Hub aid the understanding of the operation behind UPS logistics, leading to a more objective data collection. In addition, a close contact with the operation sustained the constant rearrange of the analysis model, so to incorporate specific details related with UPS operation.

<u>Oracle Database</u>

Most data collection was supported by a complex database, held by Oracle, with detailed daily information on every package processed by UPS. Data narrowing down was made over consecutive queries, followed by information filtering, according to specific software procedures.

4.1.2 Data Treatment

Data Treatment is a central activity, to guarantee a solid representation of reality, but also to prearrange the information that is going to feed the mathematical formulation. As the problem in study implies the management of Big Data, this requires special information treatment, since its size is a major drawback for most processing machines. In this sense, it is imperative to break down Big Data into smaller elements, easier to process and use special software tools that break through data in a more efficient way.

<u>Microsoft Excel</u>

The software to deal with data treatment used was Microsoft Excel, as this is very used by the company. Three Excel files, were considered, with 160K, 209K and 252K lines of UPS Residential delivery data, corresponding to 2015, 2016 and 2017, respectively. To deal with dimensions requirements, it was introduced an Excel add-in, named Kutools, which uses exact coding to process Big Data. In addition, Macros were developed through Visual Basic for Applications, to assist data treatment.

To breakdown data into more suitable input to the optimization formulation, some procedures had to be followed, specifically the dissection of Lisbon area into different areas, according to population density and the processing of delivery costs associated with the three different subcontracted companies. The unit of time to be considered was also defined. As a result, the following subsections detail how the course of action takes place.

4.1.2.1. Demand and Zip Code Locations

Zip Code locations behave as aggregation demand areas, which means that customers are distributed according to their geographical location. The Zip Code area under evaluation in the current project is portrayed in figure 25 and comprehends the region of superurban Lisbon (yellow), but also urban areas like Cascais, Oeiras, urban Lisbon area, Seixal and Barreiro (red). Although Zip number 1990 is not located in a superurban area, it is set to have a superurban compensation fee because Parque das Nações holds many top corporate and is difficult to entice local businesses to set up an UAP at their stores. Suburban/rural areas like the South shore of Tejo's River and Sintra are highlighted in blue. The distinction between these three types of areas takes particular interest for setting the corresponding UAP store fee, as described latter in cost's subsection 4.1.2.3. To better assess the results and take into to account the location of the different Zip codes, it will be set up three distinct areas of evaluation:

- **Lisbon Urban Area-** Includes all Zip codes 1xxx and it is characterized by high population density.
- **Other Urban/Suburban Areas-** Includes all Zip codes 26xx and 27xx, categorized by a mix of urban and suburban areas, located in Oeiras, Cascais, Sintra, Amadora, Odivela and Loures.
- **South shore of Tejo River-** Includes all Zip codes 28xx and is mainly featured by suburban and rural areas, with exception made for Seixal and Barreiro, where there is higher population density.

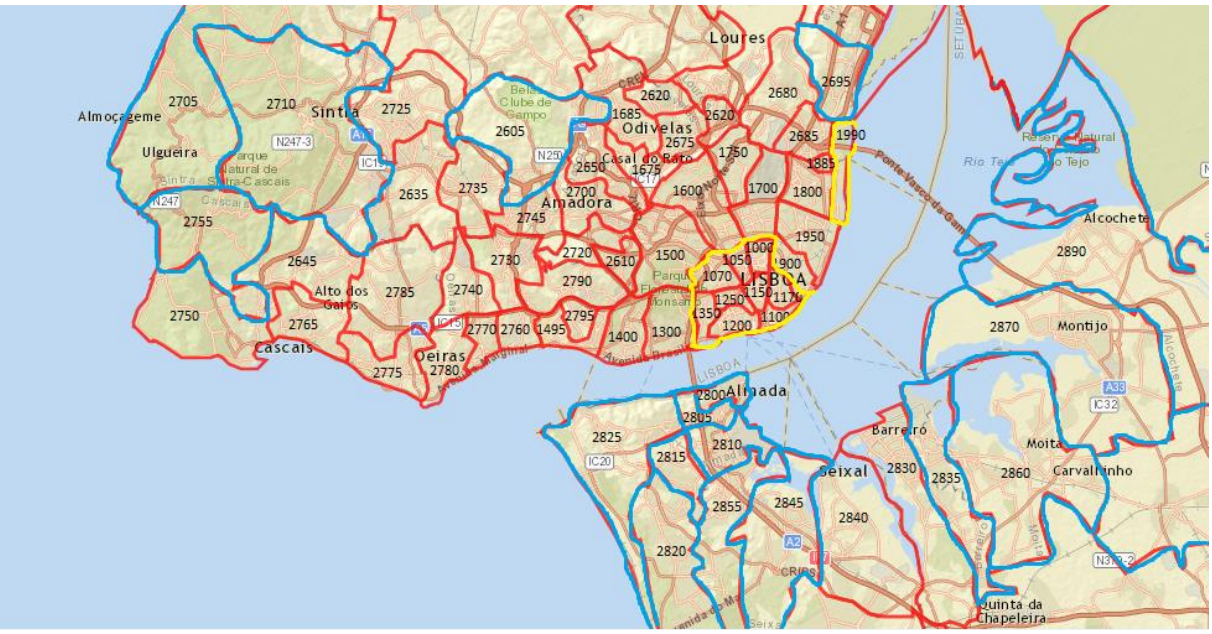

Figure 25- Zip code regions for UAP implementation. Source: *Own elaboration*

Within the three different areas of aggregation, the scope of the current work requires to assess demand not as the volume of packages delivered but as "delivery paid send again" volume, which represent the volume of unattended home deliveries. On that note, table 2 displays the volume of failed deliveries for each Zip Code number, between the years of 2015 and 2017, with proportional representative values due to confidential information. It is noticeable that all the North region of Tejo's River, comprehending Lisbon, Oeiras, Cascais and Sintra has a higher number of unattended home deliveries when compared to the South shore of Tejo's River. That association is linked with the fact that Lisbon's Northern Region has a higher delivery volume, which consequently leads to an increase in failed deliveries.

Table 2- Volume of unattended home deliveries by Zip Code location (representative values)

ZIP#	2015	2016	2017	ZIP#	2015	2016	2017
1000	681	664	911	**2700**	702	788	1053
1050	713	836	949	**2705**	566	565	613
1070	663	727	832	**2710**	669	709	878
1100	863	1175	1296	**2720**	638	695	852
1150	644	727	811	**2725**	755	706	907
1170	523	558	556	**2730**	537	554	572
1200	922	1179	1380	**2735**	607	687	834
1250	681	716	861	**2740**	504	505	514
1300	557	660	733	**2745**	770	837	1018
1350	518	546	549	**2750**	964	1509	1907
1400	550	626	700	**2755**	508	510	510
1495	580	683	846	**2760**	510	507	538
1500	883	1049	1342	**2765**	516	549	589
1600	787	996	1367	**2770**	502	500	507
1675	524	532	571	**2775**	831	982	1285
1685	528	554	561	**2780**	886	959	1008
1700	580	652	840	**2785**	682	798	974
1750	596	683	770	**2790**	638	679	734
1800	599	724	795	**2795**	579	623	675
1885	514	540	602	**2800**	614	640	734
1900	623	655	736	**2805**	500	500	503
1950	584	594	626	**2810**	548	597	679
1990	681	750	896	**2815**	523	533	558
2605	581	614	743	**2820**	610	691	769
2610	581	656	726	**2825**	572	625	743
2620	578	599	650	**2830**	605	667	771
2635	592	689	714	**2835**	576	620	700
2645	815	1034	1514	**2840**	593	643	715
2650	607	653	802	**2845**	594	670	721
2675	725	744	891	**2855**	665	795	835
2680	528	560	575	**2860**	544	609	672
2685	635	755	868	**2870**	627	693	767
2695	539	577	603	**2890**	579	658	643
TOTAL	20975	23707	27616	**TOTAL**	20514	22603	25778

4.1.2.2. Time

The time unit chosen was month, since it is the one that can better replicate accurate demand. Weekly demand can variate significantly during peak and off-peak seasons, which can lead to doubting results. The time range is thirty-six months, corresponding to the three years of operation, starting at January 2015 to December 2017, which reflect the best data related with residential deliveries, coming from increasing e-commerce business.

4.1.2.3. Costs

Costs can be grouped in two distinct ways. The first type of costs is associated with transportation and it is reflected in transportation fees, paid to subcontracted companies. These fees include cost per stop (CpS) and cost per package (CpP). As portrayed in figure 26, compensation fees are calculated based on quantity tiers, according to inverse proportion. Thus, the more stops and packages' delivery, the smaller the corresponding fee. Each outside service provider (OSP), described as LI1, LI2 and LI3 has its own fee's contract, based on average travelling distance and number of packages delivered.

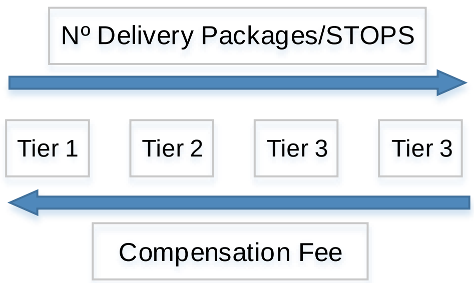

Figure 26- Compensation fee proportion for packages and stops

Both CpP and CpS portrayed in table 3 and table 4 respectively, are calculated taking into account the monthly average cost, noting that for each OSP there is a specific monthly compensation according to the number of packages and stops. All values displayed in table 3 and 4 are representative due to confidential operational information and intend to give a sense of proportion for CpP and CpS evolution, but also aims to show the contrast between both costs. Outside service providers operation is done according to the following procedures: LI1 and LI3 share the delivery operation in Lisbon, Oeiras and Cascais, where there is a higher population density and hence a smaller average travelling distance for package delivery. On the other hand, LI2 holds the highest CpP and CpS, since it operates in the south bank of Tejo's River, where in average it must drive longer distances to deliver a package.

To calculate the average annual CpP and CpS per Zip number, first it is required to aggregate all the deliveries made to a certain Zip code and account the corresponding cost, according to the OSP provider and its matching fee at the time.

Table 3- Cost per Package Delivered (CpP) in units of measure (um). Source: UPS

Year	2015			2016			2017		
OSP	**LI1**	**LI2**	**LI3**	**LI1**	**LI2**	**LI3**	**LI1**	**LI2**	**LI3**
Jan.				x + 0.07	x + 0.14	x + 0.04	x + 0.05	x + 0.22	x
Feb.				x + 0.07	x + 0.14	x + 0.04	x + 0.05	x + 0.3	x
Mar.				x + 0.07	x + 0.14	x + 0.04	x + 0.05	x + 0.22	x
Apr.				x + 0.07	x + 0.14	x + 0.04	x + 0.06	x + 0.23	x
May	x + 0.08	x + 0.16	x + 0.05	x + 0.07	x + 0.24	x + 0.01	x + 0.06	x + 0.22	x
Jun.	x + 0.08	x + 0.15	x + 0.05	x + 0.06	x + 0.23	x + 0.01	x + 0.05	x + 0.21	x
Jul.	x + 0.08	x + 0.15	x + 0.05	x + 0.06	x + 0.23	x + 0.01	x + 0.04	x + 0.19	x
Aug.	x + 0.08	x + 0.16	x + 0.05	x + 0.06	x + 0.24	x + 0.01	x + 0.06	x + 0.21	x
Set.	x + 0.08	x + 0.16	x + 0.05	x + 0.06	x + 0.23	x + 0.01	x + 0.05	x + 0.2	x - 0.01
Oct.	x + 0.07	x + 0.15	x + 0.04	x + 0.05	x + 0.23	x	x + 0.05	x + 0.2	x - 0.01
Nov.	x + 0.07	x + 0.16	x + 0.04	x + 0.04	x + 0.23	x	x + 0.04	x + 0.18	x - 0.02
Dec.	x + 0.06	x + 0.14	x + 0.02	x + 0.02	x + 0.19	x - 0.02	x + 0.01	x + 0.17	x - 0.04

Table 4- Cost per Stop (CpS) in units of measure (um). Source: UPS

Year	2015			2016			2017		
OSP	**LI1**	**LI2**	**LI3**	**LI1**	**LI2**	**LI3**	**LI1**	**LI2**	**LI3**
Jan.				x + 0.96	x + 2.58	x + 0.59	x + 0.84	x + 2.21	x + 0.37
Feb.				x + 0.96	x + 2.6	x + 0.58	x + 0.86	x + 2.24	x + 0.38
Mar.				x + 0.98	x + 2.59	x + 0.6	x + 0.88	x + 2.27	x + 0.39
Apr.				x + 0.95	x + 2.55	x + 0.57	x + 0.88	x + 2.27	x + 0.37
May	x + 1.02	x + 2.71	x + 0.66	x + 0.97	x + 2.44	x + 0.45	x + 0.89	x + 2.22	x + 0.38
Jun.	x + 1.03	x + 2.69	x + 0.66	x + 0.95	x + 2.36	x + 0.44	x + 0.84	x + 2.09	x + 0.36
Jul.	x + 1.03	x + 2.67	x + 0.66	x + 0.96	x + 2.35	x + 0.45	x + 0.79	x + 1.97	x + 0.31
Aug.	x + 1.04	x + 2.71	x + 0.68	x + 1.01	x + 2.4	x + 0.49	x + 0.9	x + 2.07	x + 0.41
Set.	x + 1.03	x + 2.7	x + 0.66	x + 0.96	x + 2.36	x + 0.44	x + 0.81	x + 2.01	x + 0.3
Oct.	x + 1	x + 2.67	x + 0.63	x + 0.91	x + 2.3	x + 0.38	x + 0.76	x + 1.94	x + 0.25
Nov.	x + 1.01	x + 2.69	x + 0.63	x + 0.82	x + 2.23	x + 0.34	x + 0.66	x + 1.83	x + 0.18
Dec.	x + 0.86	x + 2.46	x + 0.44	x + 0.56	x + 1.91	x + 0.16	x + 0.38	x + 1.67	x

The other category of costs is related with UPS Access Points (UAP) operation, according to the number of delivered packages and population density. As portrayed in Table 5, UAP fees are directly proportional to population density, translating the higher business costs of urban stores. In addition, there is a fixed cost associated with the installation of UAP point of sale (CAP). Still, in UAP cost's category there are special cost per package (CpPAP) and cost per stop (CpSAP) fees, resulting from an improved delivery and pickup system, compared to residential operations (see Table 6). Operational costs in area k are divided in two sets, k1 for for Lisbon urban area and other urban/sub-urban areas, while k2 is defined for the South shore of Tejo's River.

Table 5- UAP Store Fee for Population Density in area j

Population Density	Superurban	Urban	Suburban/Rural
Fee/Package Deliv.	CAP_{j1}	CAP_{j2}	CAP_{j3}

Table 6- UAP Operation Cost in area k

Fee/Package Delivered	$CpPAP_{k1}$	$CpPAP_{k2}$
Fee/STOP	$CpSAP_{k1}$	$CpSAP_{k2}$

4.2. Forecast

Considering the progress of residential delivery for B2C segment and consequently the increment of unattended home deliveries, around 55% annual growth from 2015 to 2017 (table2), it is relevant to present some future sustainability to the project. For that matter, it will be used a forecast approach that considers the years between 2015 and 2017, and intends to conjecture the years of 2018, 2019 and 2020. Although failed residential deliveries have a steady growth around 55%, from 2015 to 2017, if the focus is changed to Zip number detail, the fluctuations have a broader variation. In order to achieve a suitable representation of the real case study, UPS set some requirements around a multi-scenario analysis, ranging from a Pessimist to an Optimum scenario, accordingly to three main variables: number of Delivery Paid Send Again, Cost per Package (CpP) and Cost per Stop (CpS). To cope with that, the forecast approach is built around three scenarios: Most likely, Pessimist and Optimist.

Most likely scenario is created by using the forecasted values, while Pessimist setup is shaped with the upper confidence values from Delivery Paid Send Again, CpP and CpS. On the other hand, Optimistic scenario is built around lower confidence values from Delivery Paid Send Again, CpP and CpS. Optimistic scenario is designed with lower values of failed deliveries, meaning that it is considering the best-case scenario where the number of failed deliveries corresponds to an absolute minimum. On the other hand, the Pessimistic scenario is created with higher values of Delivery Paid Send Again, portraying worst-case scenario where there is an increase in failed delivery attempts. Both scenarios intend to portray the min and max states, respectively. The formulas used in forecasting data, through Microsoft Excel, run the AAA version of the Exponential Smoothing (ETS) algorithm, which is based on Holt-Winters method. Microsoft Excel is the eligible tool to be used in the forecast process because it is a flexible forecasting tool and it is aligned with UPS requirements for a common and user-friendly tool that can be easily shifted for further future analysis. The exponential Smoothing method is chosen, particularly due to its effectiveness for short-term forecasting precision, taking advantage of a prior forecast plus a weighted correction error. The forecasts were evaluated for the 66 Zip numbers under assessment in the current work, setting a 95% confidence interval. Forecasting data were evaluated for Delivery Paid Send Again, CpP and CpS. As an example, Figure 27 exhibits the forecast for Delivery Paid Send Again, regarding Zip number 1350, horizontal axis displays yearly evolution and vertical axis the absolute values for unattended deliveries.

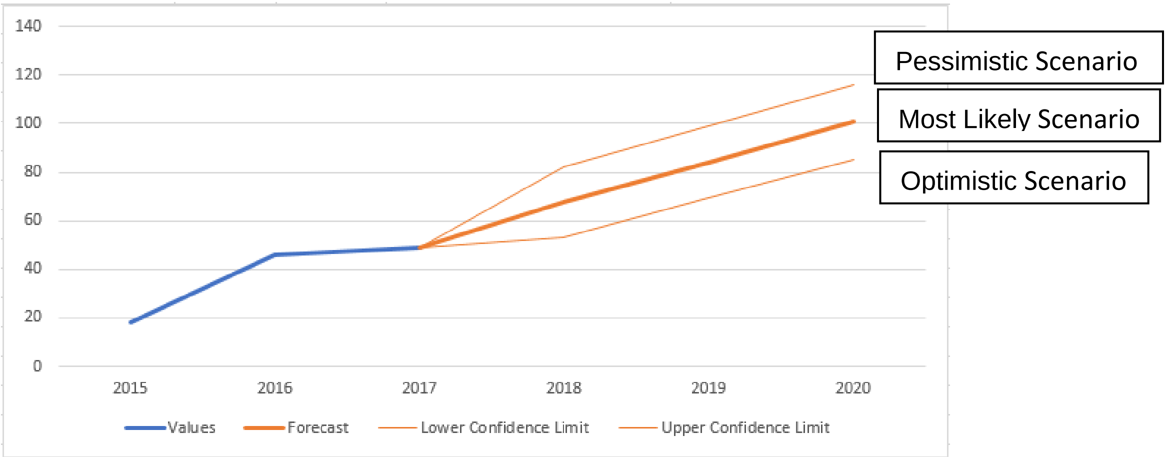

Figure 27- Forecast ETS algorithm example for Zip Code 1350. Source: *Own elaboration*

4.3. Chapter Conclusions

The current chapter starts setting the main characteristics of the problem under study and focus on gathering and processing all relevant data, in order to present a robust three scenario forecasting assessment that will set the groundwork for the case study resolution. The scope of the data evaluated range from volume of unattended home deliveries to operational costs, related not only to the number of stops attempts and number of packages delivered, but also to UPS Access Point related activities, such as fixed costs and store fees. Thus, with all data treatment and forecasting evaluations that took place it was possible to create a Most Likely scenario that will feed the parameters running in the mathematical formulation to be described in the next section.

5. Case Study Resolution

The current chapter intends to bring clarification on which locations should UPS open an UAP, in order to optimize the global distribution network in the area of Lisbon. Therefore, three distinct scenario approaches are run in the linear optimization formulation built on Microsoft Excel and the different results are compared. The most Likely scenario uses as inputs the most expected values for Deliveries Volume, CpP and CpS. On the other hand, Pessimist scenario runs the input values for most failed Deliveries Volume and higher CpP and CpS, while Optimist scenario implements the input values with lower unattended Deliveries Volume and lower CpP and CpS.

After obtaining the UAP Zip location, the process is designed to find the best locations for the UAP within the Zip code, searching for the APNID (Access Point Need ID). APNID are broader areas with potential to setup UAP locations and their calculation relies on two distinct metrics - PSI and NCI. PSI stands for Proximity Satisfaction Index and it is a measure of the distance between customers and UAP locations. PSI is inversely dependent on population density range, as displayed on table 7.

Table 7- Proximity Satisfaction Index (PSI) definition

Density Area	Maximum Distance (PSI)
Super-Urban	0.8 Km
Urban	1.5 Km
Sub-Urban	5 Km
Rural	8 Km

NCI- Network Convenience Index measures the availability of the network in terms of opening hours. To design the most suitable areas to open UAP, it is mandatory to use software MapPoint, which portrays an image of distribution volume. Figure 28 exhibits a framework for case study resolution, showing that UAP location process is complex and relies on different performance tools.

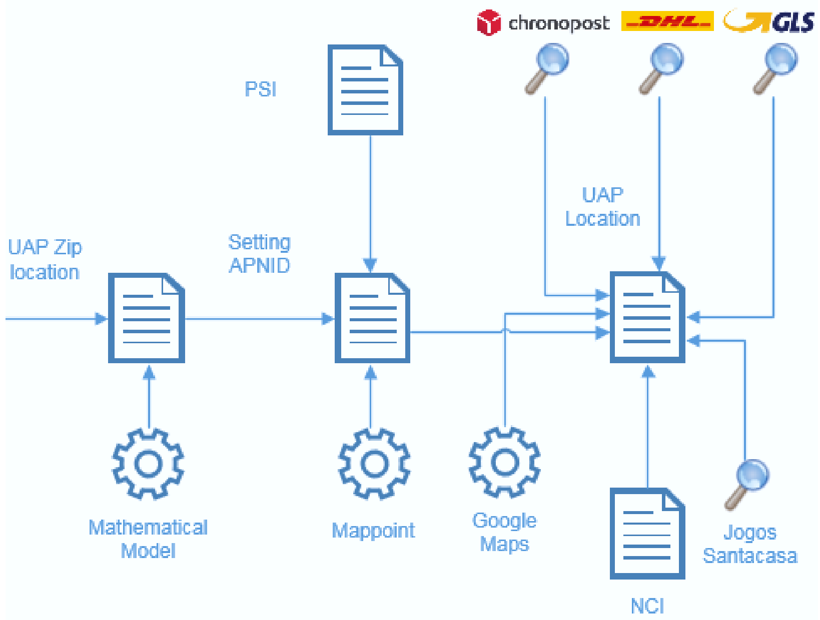

Figure 28- Case study operative framework resolution. Source: *Own elaboration*

First, cost optimization model defines which Zip codes qualifies to open UAP locations and sets the upper bound limit for the number of different sites. Afterwards, each Zip code presented as a solution in mathematical formulation is run on the MapPoint software to assess the delivery volume and define APNID areas, accounting for PSI distances. The next step on the operative framework displayed in figure 28 was introduced as a requirement from UPS with the intent to make also an assessment of the competition, leading to a more robust suggestion on the number of potential UAP locations. The goal was to setup a more comprehensive study that would assess the viability of UAP locations from an economical point of view, but also taking into account customer satisfaction with the assurance of proximity (PSI) and convenient working hours (NCI). On a different note, UPS solicitated that it was also necessary to understand their own market positioning against its rivals, in order to evaluate the necessity to open strategic UAP locations from a market share perspective. Thus, last-mile logistics network of UPS's main competitors was also in for analysis by using Chronopost pickup network locator, DHL service point locator and GLS parcel shop locator. Jogos Santacasa mediators are also considered to present the best solution options and assure NCI, since it is mandatory to be open at least 8 hours daily, from Monday to Friday and Saturday morning. Google Maps tools assists for visual enhancement of UAP potential locations.

5.1. Cost Optimization Formulation

The cost optimization consists on the minimization of a single function that is created based on UPS delivery standards and closely related with the operation costs associated with the different postal zones (J). As displayed in figure 29, for each zip code it is assessed the cost difference between UPS standard solution and UAP implementation.

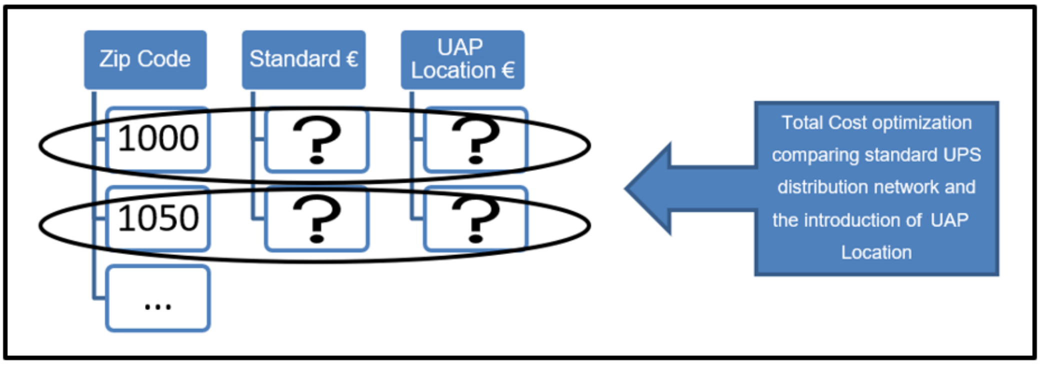

Figure 29- Cost assessment between Standard and UAP models for each individual Zip code area. Source: Own elaboration

The cost for each Zip code is assessed using the function c portrayed in figure 30, which runs a comparison between costs associated with UAP implementation and costs related to Standard UPS operation. First term replicates existing standard UPS distribution process, with current delivery costs per package and per stop. On the other hand, second term accounts for the option of setting up an UAP location and reflects all associated costs, such as fixed costs of installing an UPS terminal at the UAP, specific delivery costs by package and by stops and UAP fee per package delivered. After the evaluation of every Postal code, if the cost difference is negative, it means that UAP is not a profitable solution at this point and it will not be considered for the specific Zip Code. On the other hand, if the cost difference is not negative as displayed on the right branch of figure 30, the value will then be divided by CFAP (Fixed Cost for setting up an UPS Access Point), to determine how many potential UAP locations can

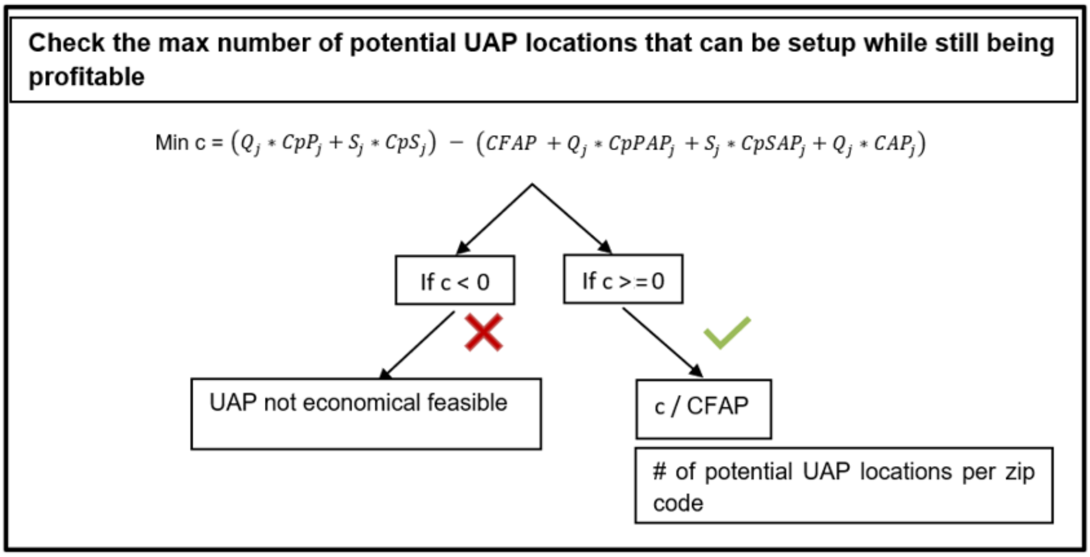

Figure 30- Mathematical formulation to minimize operational cost for each Postal code location.

be setup. Parameter CFAP is the only one that is not affected by UAP location, meaning that regardless of where it is located the value is fixed.

In order to have a clear understanding of figure 30 here follows the details for the set and parameters used in objective function c (eq (1)). As previously mention, all parameters with exception for CFAP – Fixed Cost for setting up an UPS Access Point, are dependent on Postal Code zone *j*. The reason why CFAP does not rely on Zip code areas is that this is a fixed cost associated with setting up an UPS Access Point and it is basically related with the end-point machine necessary to operate the registration of each package arriving or leaving the store.

Set

J – Set of all different Postal codes *j*

Parameters

- Q_j – Number of Residential Deliveries in postal zone *j*
- S_j – Number of Stops in postal zone *j*
- CpP_j – Cost per Residential Package delivered in postal zone *j*
- CpS_j – Cost per Residential Stop in postal zone *j*
- $CpPAP_j$ - Cost per Package delivered at UPS Access Point in postal zone *j*
- $CpSAP_j$ - Cost per Stop at UPS Access Point in postal zone *j*
- CFAP – Fixed Cost for setting up an UPS Access Point
- CAP_j – Fee paid per package delivered at UPS Access Point in postal zone *j*

$$Min\ c = \left(Q_j * CpP_j + S_j * CpS_j\right) - \left(CFAP + Q_j * CpPAP_j + S_j * CpSAP_j + Q_j * CAP_j\right) \quad \text{[Eq (1)]}$$

The optimization formulation is applied to the Zip codes comprehended in the 3 big aggregation areas already described in subsection 4.1.2.1., Lisbon Urban area, Other Urban/Suburban areas and South shore of Tejo's River. Next subsections will deeper assess each of the previous mention areas and apply the optimization formulation, in order to present the Postal code locations that would benefit from UAP implementation, as well as the number of potential UPS Access Points.

5.1.1. Lisbon Urban Area

For the 23 Zip numbers located in Lisbon urban area the results for the three different scenarios present the same conclusions, regarding the absolute value and location of UAP. However, there are significant differences in total cost values. Optimist scenario is developed from failed deliveries´ perspective and from that viewpoint, the fewer unattended deliveries, less costs related to failed deliveries. On the other hand, pessimistic scenario is built around the premises of more failed deliveries and thus, higher transportation costs. Table 8 displays the three different scenarios, with a binary variable that simulates the decision to open (1) or not to open (0) a UAP at a specific Zip number. In addition, the number of UAP (# UAP) column, refers to the potential number of UAP that can be open, so that it is still preferable to the current operation model, cost-wise. Whenever the binary variable assumes value 1, total cost is considered for just 1 UAP, by default. As portrayed in Table 8, the number of potential UAP locations is not an integer value for most Postal Codes, i.e., for Zip Code 1070 it is referred that it can be open up to 1,9 UAP for Most Likely scenario to reach an economical breakeven point. However, in real life the decision is whether to open 1 or 2 UAP locations and this more detailed analysis on the specific number of UAP to be open will take place in section 5.2.2., considering customer's Proximity Satisfaction Index (PSI), which is a relevant UPS requirement.

Table 8- Number of potential UAP locations in Lisbon Urban area and respective cost (um)

	Most Likely			Pessimist			Optimist		
ZIP#	Bin. Var.	# UAP	Total Cost	Bin. Var.	# UAP	Total Cost	Bin. Var.	# UAP	Total Cost
1000	0	0,1	3.299,03	0	0,3	4.275,11	0	-0,1	2.365,19
1050	1	1,6	4.294,32	1	1,7	4.326,68	1	1,5	4.261,96
1070	1	1,9	3.242,66	1	2,1	3.375,33	1	1,7	3.110,00
1100	0	0,2	6.978,02	0	0,4	7.697,83	0	0,0	6.272,53
1150	0	0,0	2.597,69	0	0,0	2.631,32	0	-0,1	2.564,13
1170	0	0,0	511,27	0	0,0	641,65	0	0,0	385,10
1200	1	5,4	7.902,11	1	5,6	8.083,31	1	5,2	7.720,90
1250	1	1,7	3.397,45	1	2,0	3.753,38	1	1,5	3.041,52
1300	1	1,7	2.743,69	1	1,8	2.838,09	1	1,6	2.649,28
1350	0	0,3	646,22	0	0,4	780,42	0	0,3	517,97
1400	1	1,5	2.405,29	1	1,5	2.411,59	1	1,4	2.399,00
1495	1	2,5	3.740,92	1	2,6	3.929,74	1	2,3	3.552,11
1500	1	5,3	7.339,44	1	5,8	7.739,10	1	4,9	6.939,79
1600	1	5,3	8.083,32	1	5,8	8.593,12	1	4,8	7.573,53
1675	0	0,5	855,66	0	0,6	1.001,03	0	0,4	711,75
1685	0	0,4	746,11	0	0,5	835,80	0	0,4	657,01
1700	0	0,2	3.181,33	0	0,4	3.640,51	0	0,0	2.738,49
1750	0	0,2	2.447,46	0	0,3	2.510,31	0	0,0	2.384,61
1800	0	0,2	2.773,76	0	0,3	3.012,23	0	0,1	2.542,36
1885	0	0,1	1.017,61	0	0,1	1.160,34	0	0,0	879,66
1900	0	0,2	1.899,90	0	0,2	2.090,36	0	0,1	1.713,69
1950	0	0,1	921,43	0	0,1	1.018,02	0	0,0	828,21
1990	0	0,1	3.332,93	0	0,3	3.652,61	0	0,0	3.022,14

Looking at the results presented in table 8 it is possible to infer that the decision on which Zip Codes to open UAP locations it is not affected by the variation on failed delivery attempts and also the fluctuation of both cost per package (CpP) and cost per stop (CpS) based on the Upper and Lower bounds of the forecasts. Nevertheless, the number of potential UAP locations are different across the three different scenarios. Recalling figure 25, the area of superurban population density, ranging from Zip Code 1000 to 1350, excluding Postal Code 1300 and including 1990, indicates that in order to make UAP a viable solution from an economical point of view, a high volume of failed home deliveries is required, showed by a high value on the total cost column. There are some exceptions to that as Zip codes 1000 and particularly 1100 present high volume of unattended home deliveries (displayed in table 2) and consequently a high total cost for operation, as portrayed in table 8.

In the particular case of Postal Code 1100 when we drilldown to understand why such a high volume of failed deliveries does not suggest the opening of UAP locations, it is due to the nature of this area. Zip Code 1100 holds the areas of Rossio and Praça do Comercio characterized for high volume of business stores where it is easy to concentrate multiple packages deliveries with just one stop and thus, reducing operation costs. In addition, it also holds the areas of Alfama and Mouraria defined with very high customer density where it is also possible to take advantage of multi package delivery with a single stop. If we recall the operation's cost model described in subsection 4.1.2.3 it is noticeable that number of stops are the most expensive variable accounting for UPS's distribution cost structure. Being able to reduce significantly the cost related with number of stops makes that even for a high volume of unattended home deliveries UAP does not stand a change compared to UPS standard delivery process.

5.1.2. Other Urban/Suburban Areas

The 29 different Zip numbers located in other urban/suburban areas present similar absolute solutions on where to open UAPs. Nevertheless, differently from Lisbon urban area where there was no impact on the Zip Codes where to open UAP locations for all three scenarios, table 9 reveals that for Other Urban/Suburban Areas there are some differences on the locations of UAP. Assessing these differences, it is possible to sustain that Zip code 2635 should not open a UAP location for Optimistic scenario, but can open 1 UAP, both for the Most Likely and Pessimist scenarios. In this particular case, the reduction of failed deliveries results in a decrease of the operation costs and ultimately leads to a higher economic benefit using UPS standard distribution process. On a different note, Zip number 2750 which presents the highest volume of unattended deliveries can benefit from UAP for Most Likely and Pessimist scenarios and according to Optimistic setup is preferable not to open UAP. It might come out strange how such a high volume suggests that no UAP location is opened, but when compared against the Lower Bound forecasting of the Optimistic scenario for CpP and CpS, the cost for UPS standard logistics turns out to be lower than setting up UAP locations.

Taking in consideration the data from table 9 and similar to what is described in section 5.1.1. for Lisbon Urban Area, it is clear that for the most part Postal Codes with higher failed deliveries and thus, higher total costs are in favor for the introduction of UAP locations. The great exceptions to previous statement are Carcavelos (2775) and Alcabideche (2645) that due to the nature of its operation costs, not even for worst-case scenario (Pessimist) in terms of volume and costs, considers the opening of UAP locations. Upon further research on these 2 Zip Codes, assisted by UPS Operations department it is possible to conclude that the advantages of the operation costs for the two Postal Codes mentioned before lies on the fact that deliveries concentration and traffic flow create such an efficient distribution network that makes It more profitable than adding another layer of distribution by implementing UAP locations.

Table 9- Number of potential UAP locations in Other Urban/Suburban Areas and respective costs (um)

	Most Likely			Pessimist			Optimist		
ZIP#	Bin. Var.	# UAP	Total Cost	Bin. Var.	# UAP	Total Cost	Bin. Var.	# UAP	Total Cost
2605	1	1,7	2.551,16	1	1,9	2.844,72	1	1,4	2.257,59
2610	1	1,6	2.519,49	1	1,6	2.535,23	1	1,6	2.503,76
2620	0	0,9	1.649,45	1	1,0	1.791,33	0	0,8	1.497,68
2635	1	1,1	2.393,71	1	1,25	2.620,29	0	0,9	2.138,81
2645	0	0,4	9.086,50	0	0,7	10.060,95	0	0,2	8.132,64
2650	1	2,1	3.091,72	1	2,4	3.415,85	1	1,8	2.767,59
2675	1	2,3	3.387,91	1	2,6	3.790,71	1	1,9	2.985,11
2680	0	0,5	941,18	0	0,6	1.025,34	0	0,5	858,20
2685	1	2,5	3.742,59	1	2,6	3.764,61	1	2,4	3.720,56
2695	0	0,7	1.277,23	0	0,8	1.344,82	0	0,6	1.210,73
2700	1	3,6	5.184,75	1	4,2	5.748,04	1	3,1	4.621,46
2705	0	0,1	844,10	0	0,2	1.032,55	0	0,1	663,88
2710	0	0,4	3.120,06	0	0,6	3.615,00	0	0,2	2.641,45
2720	1	2,3	3.460,80	1	2,6	3.775,49	1	2,0	3.146,11
2725	0	0,6	3.058,64	0	0,8	3.981,34	0	0,4	2.153,99
2730	0	0,4	806,39	0	0,4	813,55	0	0,4	799,26
2735	1	2,3	3.463,84	1	2,4	3.674,68	1	2,1	3.253,00
2740	0	0,0	112,88	0	0,0	144,75	0	0,0	83,73
2745	1	3,1	4.510,25	1	3,5	4.868,99	1	2,8	4.151,51
2750	1	1,0	13.155,30	1	1,5	13.617,89	0	0,6	12.481,80
2755	0	0,0	62,73	0	0,0	69,42	0	0,0	56,15
2760	0	0,0	325,97	0	0,1	470,75	0	0,0	198,34
2765	0	0,2	950,86	0	0,2	992,15	0	0,1	910,40
2770	0	0,0	55,86	0	0,0	85,57	0	0,0	26,74
2775	0	0,5	6.733,50	0	0,8	7.372,24	0	0,3	6.113,18
2780	0	0,4	3.563,00	0	0,5	3.691,31	0	0,3	3.436,79
2785	0	0,3	4.179,84	0	0,5	4.486,30	0	0,1	3.883,03
2790	1	1,4	2.284,75	1	1,4	2.328,80	1	1,3	2.240,69
2795	1	1,1	1.976,84	1	1,2	2.002,01	1	1,1	1.951,66

5.1.3. South shore of Tejo's River Area

The 14 Zip codes located in South shore of Tejo's River area reveal resembling absolute values for UAP location. Yet, table 10 shows that Zip code 2815 can sustain an UAP location for Pessimist scenario, but should maintain the standard distribution network for both Most Likely and Optimist scenarios. Once again, if we access the volumes of failed deliveries displayed in table 2 it is noticeable that in the South shore of Tejo's River both Zip codes 2805 and 2815 are the ones with the lowest volumes. For Postal code 2805 the values for unattended home deliveries are so insignificant that the introduction of UAP locations would only increase the operations' costs. Furthermore, Zip code 2815 also displays small volume of failed deliveries and only for Pessimist scenario where these volumes increase, it is reached a profitable point for a UAP solution.

Table 10- Number of potential UAP locations in South shore of Tejo's River and respective cost (um)

	Most Likely			Pessimist			Optimist		
ZIP#	Bin. Var.	# UAP	Total Cost	Bin. Var.	# UAP	Total Cost	Bin. Var.	# UAP	Total Cost
2800	1	3,6	2.312,39	1	4,1	2.520,34	1	3,1	2.104,45
2805	0	0,1	60,95	0	0,1	83,62	0	0,0	39,63
2810	1	3,2	2.115,85	1	3,4	2.216,76	1	2,9	2.014,94
2815	0	1,0	985,40	1	1,1	1.057,68	0	0,8	882,42
2820	1	4,4	2.756,09	1	4,5	2.765,27	1	4,3	2.746,92
2825	1	4,1	2.624,61	1	4,7	2.823,38	1	3,6	2.425,84
2830	1	4,5	2.827,81	1	4,8	2.959,98	1	4,1	2.695,64
2835	1	3,4	2.185,47	1	3,7	2.295,56	1	3,1	2.075,39
2840	1	3,4	2.314,75	1	3,6	2.383,98	1	3,1	2.245,51
2845	1	3,6	2.362,46	1	3,9	2.438,91	1	3,4	2.286,01
2855	1	5,4	3.229,21	1	6,1	3.504,43	1	4,7	2.954,00
2860	1	3,2	2.094,74	1	3,2	2.100,86	1	3,1	2.088,63
2870	1	4,2	2.638,15	1	4,3	2.662,61	1	4,1	2.613,69
2890	1	2,3	1.695,02	1	3,0	1.982,47	1	1,7	1.407,57

Taking into account the volumes portrayed in table 2 it, is clear that most of Zip codes 28xx present smaller failed delivery volumes than other Postal codes from Lisbon urban/suburban areas. Still, almost all Zip codes from South shore of Tejo's River could benefit from UAP solutions, in opposition with other Postal codes in urban Lisbon with higher unattended delivered volumes, where it would not be profitable. The main reason for that is the specifics of the operational cost structure of Zip codes located in this area. As previously shown, the cost per package delivered (CpP) and cost per stop (cpS), tables 3 and 4 respectively, indicate that outside service provider LI2, responsible for the area of South shore of Tejo's River, presents the highest operational costs. Especially when it is taken under consideration the costs per stop, which represent the biggest stake of the cost structure, the area of South shore displays almost twice the costs of Lisbon urban/suburban area. The significant cost difference that makes UAP solution very suitable to the area of South shore relies on the premises that in average the distance between deliveries is much higher for Zip Codes 28xx, due to the geographical nature of the area. In that sense, the financial impact of a failed delivery is much higher for the South shore area, despite the relative lower volume of unattended home deliveries, resulting in a very big advantage for UAP solution, as displayed in table 10.

5.2. Scenario Evaluation

After the definition of the mathematical formulation to be implemented and the results obtained for three scenarios based on the forecasted values for the volume of unattended home deliveries displayed in section 5.1., in this section a scenario evaluation between Optimist, Most likely and Pessimist takes place, in order to assess the best scenario to represent the optimization of UAP network. As described in previous sections, the 3 scenarios are a result of the necessity to better handle the uncertainty that follows the forecasting of both volume of home deliveries and UPS logistics' cost structure. On that note, after knowing the profitable number of potential UAP location evaluated in section 5.1. it is important now to drilldown the different scenarios and find out which better represent the UAP implementation problem.

In order to have a better feeling about the different scenarios, it is imperative to clarify that the UAP solution is compared against current solution operated by UPS, in all three different areas displayed previously in figure 25 and for all three different scenarios. In addition to cost comparison, it is also assessed the number of potential UAP locations per area, as displayed in table 11.

Table 11- Exhibits total costs for a UAP solution and current costs for standard solution (um)

SCENARIO	AREA	UAP COST (UM)	CURRENT COST (UM)	POTENTIAL UAPs
OPTIMIST	**Lisbon Area**	**76537,62**	**77580,1**	**13**
	Urban/Suburban areas	**80885,9**	**86531**	**16**
	South shore of Tejo's River	**28580,6**	**44572,1**	**37**
	Total	178297,4	208683,2	73
MOST LIKELY	**Lisbon Area**	**74357,6**	**84138,7**	**22**
	Urban/Suburban areas	**88491,3**	**95589,3**	**22**
	South shore of Tejo's River	**30202,9**	**48329,1**	**41**
	Total	193051,9	228057,1	85
PESSIMIST	**Lisbon Area**	**79997,9**	**90840**	**23**
	Urban/Suburban areas	**95964,7**	**104828,4**	**24**
	South shore of Tejo's River	**31795,9**	**52161,1**	**44**
	Total	207758,4	247829,5	91

From table 11 it is clear that the best solution from a cost perspective would be the introduction of a "mixed UAP solution" for the Zip Codes in green displayed in subsections 5.1.1., 5.1.2 and 5.1.3, meaning that for those Postal Codes where setting an UAP is more profitable, UPS should consider the introduction of the UAP, while for those where current solution reveals more lucrative, no further action should be taken. When looking at the three scenario's evaluation it is noticeable that the optimist scenario presents the lowest costs, since it considers a reduction in failed delivery attempts. However, as explained in section 4.2., forecasts show a tendency for increasing failed deliveries, as a consequence of increasing overall delivery volumes. For that reason, the two best scenarios to represent the UAP location problem are Most likely and Pessimist. When comparing these two previous scenarios, UPS was consulted in order to give feedback in which scenario would be a better fit for the problem representation. Despite the fact that deliveries' volume is increasing and consequently failed deliveries are also in a rise, UPS is taking different actions to try to minimize the unattended deliveries, such as pre-informing customers about the delivery slots and making these slots more specific in time to make sure customers can make time to receive their packages. Taking all that into consideration, Most likely scenario is the front runner and from now on it will be the focus of this research.

The proposed solution results better when compared to the UPS solutions. The differences between total costs for a solution with UAP locations (193051,9 units of measure um) and current standard process with reverse logistics and send again (228057,1 um), for Most likely scenario as displayed in Table 11, the potential cost saving of shifting from UPS current distribution process to a solution that would implement UAP locations on the profitable zip code areas can be calculated using the values of both total costs mention previously and representing around 35K um, which is 15,4% of current solution costs. On the other hand, Most-likely scenario has a potential for 85 UAP locations, that will also work as a nearby point for customer satisfaction, once its locations are close to end-customer.

5.2.1. APNID and UAP potential locations

After previous section, in which the number of potential UAP locations per Zip code lane were established based on cost optimization, it is mandatory now to dive in deeper detail for each Zip code area and define the APNID (Access Point Need ID), where UAP locations must be set up. The total cost displayed in table 11 for UAP solution considers the minimum optimal cost solution, since it reflects a single UAP location per Zip code lane. Thus, it is necessary to perform another assessment in order to find the exact number of UAP locations and consequently the exact cost. On that note, here it will be performed a small review on UAP location set up methodology.

As portrayed in figure 28, APNID points are calculated based on Proximity Satisfaction Index, which are tightly connected to population density. The tool used to assist UAP network design is MapPoint, indicating residential delivery volume. For a better understanding on UAP design network model, three APNID location settings will be presented below for Zip code 1050 - Lisbon Urban Area, Zip code 2745 – Urban/Suburban Area and 2810- South shore of Tejo's River. UAP potential location for Postal code 1050 will be under a more detailed analysis in order to clearly explain the methodology used and the steps followed to come up with the UAP locations, the number of UAP and some potential third-party business stores that could work as UAPs.

1050-Campo Pequeno/Picoas

Zip number 1050 is in a super urban area, with relevant residential delivery volume and consequent failed delivery attempts (see table 2). Considering optimization, exhibit on table 8, it is beneficial to open 1,6 UAP locations for this area, comparing against the current standard UPS distribution network. Since 1,6 locations is infeasible in reality, the assessment on the number of UAPs must be done in terms of integer numbers, so in this case the decision is whether to open 1 or 2 locations. As previously stated, the maximum number of locations to make breakeven between UAP solution and standard UPS distribution network is 1,6 which means that opening 2 UAP would result in losses. However, there is a requirement named PSI (Proximity Satisfaction Index) that might force the opening of unprofitable UAP locations in order to maintain a certain service level and convenience.

As previously portrayed in figure 28 the framework for the definition of the optimum number of UPS Access Points and their location in each Zip code can be illustrated for the specific Postal code 1050 in following steps.

- **Step 1: Identify the respective PSI for Zip code 1050.** The first step of the process to access the optimized number of UAP locations to be setup in Postal code 1050 Campo Pequeno/Picoas, following the framework displayed in figure 28 to identify the Proximity Satisfaction Index, which in this particular case is defined for a super urban area as 0.8 Km (table 7). In this case, it is possible to verify in figure 31 that one UAP location would be enough to fulfil the requirement of 0.8 Km distance. In that sense, for Postal code 1050 the optimal solution cost-wise is to setup one UAP.

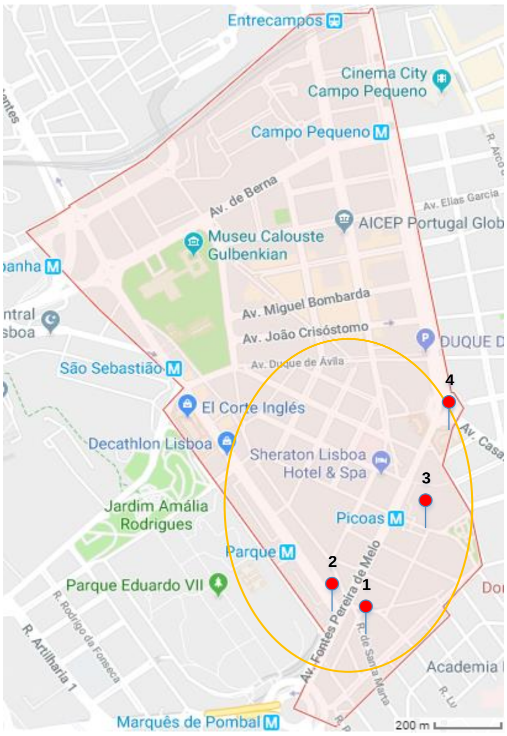

Figure 32- UAP potential location area.
Adapted from Google Maps (2018a)

- **Step 2: Use MapPoint to identify the areas with greater delivery volumes.** After knowing the maximum distance between UAP locations required by PSI it is necessary to check this constraint against the area delimited by Zip code 1050 and evaluate the number of UAP locations necessary to respect the 0.8 Km distance and still cover all customers in that residential area. In addition, it is also mandatory to assess the volumes of residential delivery through MapPoint, as showed in figure 32 and optimize customer satisfaction by opening UAP locations in areas with higher distribution volumes.

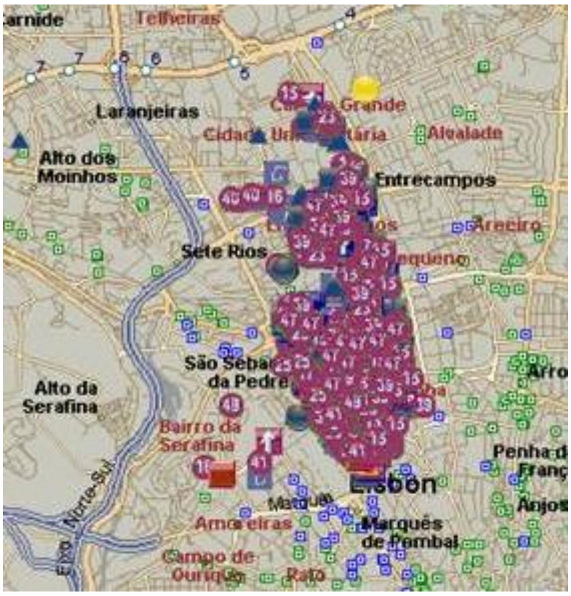

Figure 33- Residential Delivery Volume, Zip Code 1050 (2017). ***Adapted from MapPoint***

- **Step 3: Assure NCI (Network Convenience Index) as a measure of convenience in terms of UAP working hours.** Once step 2 is complete and the best areas for UAP locations are identify it is time to look for the best options in terms of working hours.

  Taking under evaluation MapPoint software, presenting residential volume as displayed in figure 32, the potential UAP location should be preferential in the lower section of Zip code 1050, closer to Picoas where the biggest delivery volume is concentrated. In case of considering a second UAP, it should be in the upper section, closer to Campo Pequeno, to improve PSI. Some potential locations for UAPs are highlighted in figure 31: 1- Papelaria do Andaluz. Address: R. de Santa Marta 28, 1050-121 Lisboa; 2- Gabi. Address: Av. António Augusto de Aguiar 1, 1050 Lisboa; 3- Papelaria São Marcos Lda. Address: R. Sousa Martins 35, 1050-129 Lisboa; 4- Livraria Almedina. Address: Praça Duque de Saldanha 1, 1050-094 Lisboa.
- **Step 4: Account for relative positioning against UPS's main competitors.** UPS requirements for the development of current research project comprehend the assessment of UPS's competitors positioning in terms of pickup/drop off locations for all Zip Codes evaluated. The need to compare against competition arises from the requirement to facilitate extra information in order to aid UPS whenever the number of potential UAPs is different than the number of required UAP locations to fulfil all the constraints related with Proximity Satisfaction Index. In this case, if the number of potential UAPs is higher than number of required UAPs, UPS suggested to use the minimum potential number of UAP that fulfil PSI requirements. However, if there is a substantial dissimilarity against competition in terms of number of pickup/delivery points, in that case further analysis should be done in order to assess whether

more UAPs should be open. In case the number of required UAPs is higher than potential UAPs it is mandatory to evaluate what is the best solution for all particular cases, if UPS should invest more and open extra locations in order to promote Proximity Satisfaction Index, or if it should neglect PSI and open less locations or even choose not to establish UAP locations at all. For all these cases extra analysis will take place in section 5.2.1.1

For Postal code 1050 as shown in table 12, setting up one UAP location is the optimal solution cost-wise and it is also in accordance with what competition has established for this area. Only GLS does not provide any pickup/delivery point in this area. Nevertheless, UPS volume of operation is more similar to Chronopost and DHL, which possess higher delivery/pickup volumes. For all reasons previously mentioned, although it can be a possibility in the future to open a second location near Campo Pequeno area, for the meantime the optimal solution indicates the opening of one location next to Picoas.

Table 12- Number of potential UPS drop-off locations vs competition for Zip Code 1050

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	1	2	1	0

2745-Queluz/Massamá

Queluz and Massamá are heavily populated areas with relevant residential delivery volume. Mathematical formulation indicates that up to three UAP can be installed in this location, with exception for optimist scenario that refers only two. Assessing both cost optimization and area potential for residential deliveries, it is counseled that two UAP should be open at Zip code 2745. Assessing both relative positioning, displayed in table 13, and taking into account that UPS is just starting the implementation of UAPs it is suggested to start with two locations to have a grasp of the business volume in Postal code 2745. The two UAP locations would be enough to cover the entire delivery zone, within the 1,5 Kilometers distance requirement for Urban areas if they are set one in each side of road IC18 as portrayed in figure 34. Later down the road if unattended delivery volumes keep increasing, UPS should consider opening two extra locations closer to road IC18, resulting in a better customer's coverage.

Table 13- Number of potential UPS drop-off locations vs competition for Zip Code 2745

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	2	5	4	3

Considering MapPoint delivery volume, displayed in figure 34, there are two different APNID areas next to Massamá and Queluz. These two APNID areas portrayed on figure 33, should hold UAP locations, comprehending following possibilities: 1- ColorSpot. Address: Rotunda Dra. Laura Aires, 2745-758 Queluz; 2- Shopping Center. Address: Av. 25 de Abril 60, 2745-733 Queluz; 3- Tabacaria O Monte. Address: R. Prof. Dr. Virgílio Machado 17, 2745-232 Queluz; 4- Lojas Carmil. Address: Av. Luís de Camões 10, 2745 Queluz.

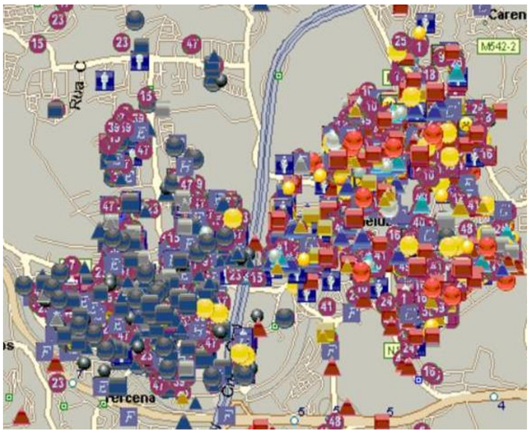

Figure 35- Residential Delivery Volume, Zip Code 2745 (2017). ***Adapted from MapPoint***

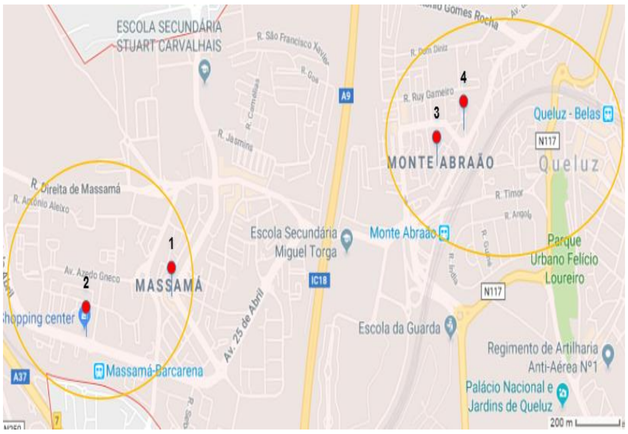

Figure 34- UAP potential location area Zip code 2745. ***Adapted from Google Maps (2018a)***

2810-Almada

Zip codes located in South shore of Tejo's River should have a deeper analysis, since this area has a higher number of potential UAP locations, due to higher costs associated with failed deliver, namely higher costs per stop. Once again in this case, parallel to Zip code 2745, there is a higher number of potential UAP locations 3 (displayed in table 10), than suggested UAP locations, 1 portrayed in table 14. Using the same logic as in Postal code 2745, it is recommended that UPS starts by opening 1 UAP location that still fits the PSI Index requirement of 5 Km distance for Sub Urban areas. Thus, it is recommended a more central location, such as location 1 or 5, so that both customers living in north and south areas can take advantage from this pickup point. If residential volume on the left side of highway A2 keeps growing, it can be considered a second location around this area in a near future.

Table 14- Number of potential UPS drop-off locations vs competition for Zip Code 2810

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	1	2	2	0

Assessing Mappoint residential deliveries' volume (see figure 35), the most attended zone is around Laranjeiro. For that reason, this area should hold an APNID (figure 36 - highlighted in yellow) with the following potential locations: 1- Papelaria Marianinha. Address: R. Dr. António Elvas, 104A 2810-166 Almada; 2- Papelaria Joaquim Graça. Address: lameda Guerra Junqueiro, 28B 2810-262 Almada; 3- Papelaria Lobalusa. Address: R. Alembrança, 42C 2810-005 Almada; 4- Havaneza do Feijó. Address: R. Alembrança, 4 2810-004 Almada; 5- Papelaria Parati. Address: R. Dr. António Elvas, Mercado Municipal do Feijó, LJ3 2810 - 165 Almada.

Figure 37- Residential Delivery Volume, Zip Code 2810 (2017). ***Adapted from MapPoint***

Figure 36- UAP potential location area Zip code 2810. ***Adapted from Google Maps (2018a)***

5.2.1.1. Specific Zip codes with strategic decisions

Looking for the optimal solution including all key steps illustrated in the last section for the specific case of Postal code 1050 we come across with some areas that cannot fulfil the required Proximity Satisfaction Index and thus a decision needs to be made whether not to open any UAP locations or to invest pass breakeven point and assume the extra cost as an investment with expected future revenues. On this note, Zip codes 1300, 2605, 2750 and 2790 require a deeper analysis taking place in this section and one that was shared and used inputs from UPS in order to find the best option aligned with the company's goals for future growth.

Taking into account the data displayed in table 15 it is clear that Postal code 2605 is the only one among the specific four previously mention that required strategic decisions, where the proposed decision is to reduce the number of UAP sites, in this particular case by not opening any location. All the other three Zip codes the suggested action was to increment the number of UAP locations and incorporate the extra cost as an investment expecting future growth. The process that leads to the suggested values portrayed in table 15 will be explained in detail for each specific Zip code.

The last column from table 15 details the extra cost associated with the decision to increment the extra UAP locations for the case of Postal codes 1300, 2750 and 2790. In the particular case of Zip code 2605 the extra cost associated with the decision not to open UAP locations arises from the fact that Standard UPS solution presents higher operational costs in this area than UAP solution would reflect. The issue with the implementation of UAPs in Postal code 2605 is that it would require 3 locations to cope with Proximity Satisfaction Index. In addition, after evaluation the distribution pattern of customers in the area of 2605 and relatively small delivery volumes, UPS agreed that the best solution at this point would be not to open any UAP locations.

Table 15- Specific Zip codes with strategic decisions and respective extra costs

ZIP#	# Potential UAP	# UAP (PSI requirement)	# Proposed UAP	UAP Diff	Extra cost (um)
1300	1.7	2	2	+	139.77
2605	1.7	3	0	-	355.72
2750	1.0	2	2	+	517.97
2790	1.4	2	2	+	343.30

1300-Ajuda

Zip code 1300 presents some interesting challenges to UPS because, although there is some delivery volume increasing around 180% in 2016 and 40% in 2017, as exhibit on table 2, this is a wide area which cannot satisfy PSI with only one UAP location. In order to setup two UAP sites required for Proximity Satisfaction Index, UPS will incur in an extra cost of around 140 units of measure (um). Despite cost increase, UPS considers it to be very marginal and worthy in the case of Postal code 1300. Potential growth of deliveries' volume and consequently failed attempts, in addition to a stronger positioning against main competitors are weighing more to UPS than the marginal loss of 140 um. Ideally, two APNID should be setup, one in Ajuda and another closer to LxFactory as displayed in figure 37 in yellow.

Figure 38- UAP potential location area Zip code 1300. *Adapted from Google Maps (2018a)*

2605-Belas/Casal de Cambra

Zip code 2605 is a particular case where there is a big area, with near 25 Km^2, but population is concentrated in two smaller areas next to Belas and Casal de Cambra, see figure 38. Considering cost optimization, it is suggested to open one UAP location, but Proximity Satisfaction Index requires 3 sites to cover all area of 25 Km^2. The tradeoff between investing in three new UAP locations in Postal code 2605 and not opening UAP's sites at all was assessed together with UPS and the decision taking into account the relative low delivery volumes displayed in table 2, was to postpone the decision at this point and keep using the standard distribution model, waiting for future delivery increase.

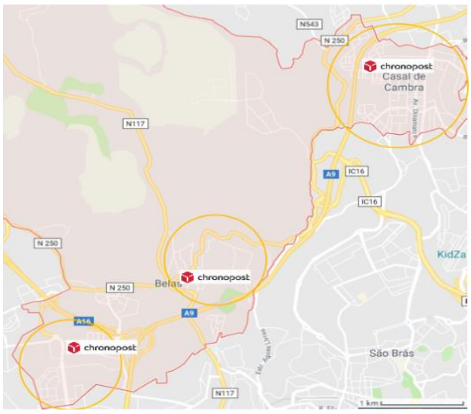

Figure 39- UAP potential location area Zip code 2605. *Adapted from Google Maps (2018a)*

Taking into account population density distribution it is possible to identify three distinct higher delivery areas, alongside highway A9, from Belas to Casal de Cambra. Despite cost optimization suggests to setup a single UAP, it wouldn´t benefit most customers due to their distance to UPS location. Thus, the alternative would be as depicted in figure 38, for Chronopost case with three different locations. Yet, UPS residential delivery volume at the moment, does not justify three UAP and for that reason, it is recommended to open no UAPs at Zip number 2605.

2750-Cascais

For Cascais Zip location (2750) both most likely and pessimist scenarios require one UAP, while optimist scenario is optimized with the current distribution procedure, without UAP's setups. Considering that Cascais presents the highest residential delivery volume and consumers have high purchasing power, it is justified at least one UAP. It would be expected that the area with highest volume of failed deliveries would suggest the opening of multiple UAP locations, but due to the high delivery volume, delivery costs with current distribution model are relatively low and that is the main reason why cost optimization suggests only 1 UAP site. However, after assessing all the pros and cons, UPS decided to go for two UAP locations, in order to optimize service level and PSI.

As previously mentioned, Cascais is by far the Zip code with highest residential deliveries' volume and a strategic region with high purchasing power and e-commerce penetration. Thus, it requires special assessment related to UAP location. Deliveries are mostly concentrated in the lower area, around de center on Cascais and for that reason, the priority UAP must be open in the central yellow circle displayed in figure 39. To consider a second location there are two different areas, one on the left and another on the right side of figure 39. Although both location 3 and 4 are in high delivery areas, it is recommended to give precedence to location 3 because it is located in a higher purchasing power area.

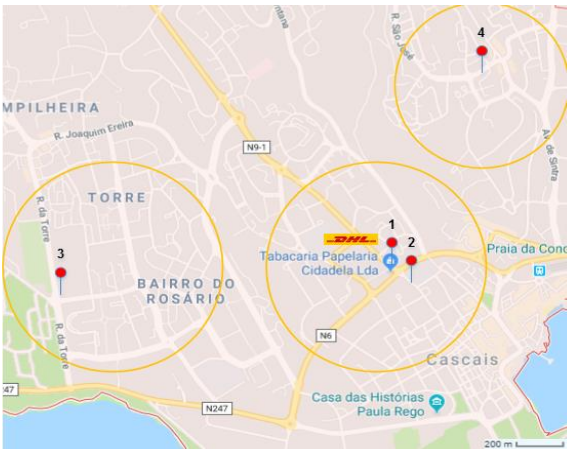

Figure 40- UAP potential location area Zip code 2750.
Adapted from Google Maps (2018a)

2790-Carnaxide/Queijas

Zip number 2790 holds two distinct areas. Carnaxide, characterized for a mix between residential and commercial services, while Queijas is mostly residential. Postal code 2790 holds a distinct feature, having two well separated areas with similar residential delivery volume as portrayed in figure 40 with two yellow lines. Although at this point in time only 1 UAP location is profitable, by choosing only one UAP site, customers further from the UAP area cannot use the pickup option because it is far away and does not comply with PSI. Considering all the above premises, it is advised to open one UAP in Carnaxide and a second one in Queijas, as displayed in figure 40. The investment cost of a second location is 343.30 um as displayed in table 15, but UPS considers it worthy when compared to the potential delivery volume of Zip code 2790 and also taking into account the Proximity Satisfaction Index that allows customers from Carnaxide and Queijas to take advantage of these UAP pickup/delivery points.

Figure 41- UAP potential location area Zip code 2790.
Adapted from Google Maps (2018a)

5.2.2. UPS Access Point Network Optimization

After assessing UPS Access Point solution and respective cost optimization in section 5.1. it is imperative to consider the constraints associated with Proximity Satisfaction Index (PSI), addressed in section 5.2.1. Thus, present section aims to balance the cost optimization performed in section 5.1., which consider only a single UAP location per Zip Code, with the corresponding costs of the suggested solution presented in section 5.2.1. which also takes into account UPS requirements for customer proximity. In a clear definition, current sub section intends to bring clarity on the costs of Proximity Satisfaction Index (PSI), since it will evaluate the cost difference between opening 1 UAP location for those areas where UAP bring economic benefit versus opening the number of UAP locations necessary to fulfil the distance requirement (PSI).

Focusing on Table 16 and comparing the results for total cost regarding an UAP solution considering Proximity Satisfaction Index, against the results for a single UAP location per Zip Code, it is verified that the cost difference associated with Proximity Satisfaction Index is around 8530 um, since respectively total cost are 201582,5 um and 193051,8 um and the gap between the number of required UAP locations is 14 (48-34). Thus, it is perceptible that there is an extra cost associated with UPS's Proximity Satisfaction Index, which determines that for a specific Postal Code each customer's house should be located within a certain distance. The conclusions regarding PSI requirement reveal that for some Zip Codes it is necessary more than one UAP location to make it acceptable for all customers within the area to have access to its services, as displayed in Figure 32 for Postal Code 2745 located in Queluz/Massamá, where 1 UAP location is recommended in each side of Highway A9. Despite the cost difference around 8530 um to respect the requirement of Proximity Satisfaction Index, when balanced against current UPS solution with complex reverse logistics, it is clear that, not only there is a savings potential of 26474,6 um, in total but also an improvement in service level by setting up 48 UAP location that work as nearby points for the end-customer.

Table 16- Total costs for an UAP solution single location vs PSI and current costs for standard solution

SCENARIO	AREA	UAP COST (UM) 1 LOCATION	NUMBER OF UAPs	UAP COST (UM) (PSI)	NUMBER OF UAPs (PSI)	CURRENT COST (UM)
MOST LIKELY	**Lisbon Area**	**74357,6**	**9**	**76537,6**	**13**	**84138,7**
	Urban/Suburban areas	**88491,3**	**13**	**93207**	**20**	**95589,3**
	South shore of Tejo's River	**30202,9**	**12**	**31837,9**	**15**	**48329,1**
	Total	193051,8	34	201582,5	48	228057,1

5.3. Sensitivity Analysis

During the development of this work, mainly in section 5.1. with mathematical formulation, there is a clear distinction between the costs associated with a standard residential delivery and UPS Access Point delivery. Accordingly, it is important to evaluate the uncertainty impact of the parameters that affect final costs. Since residential CpP and CpS are well known parameters, negotiated with distribution outside service providers, sensitivity analysis will focus on the costs associated with UPS Access Point activities. These costs related with UAPs are based on theoretical estimates indexed to UPS Spanish model and represent higher variability and uncertainty.

Due to the complexity and extension of data, the emphasis of sensitivity analysis will be on the Most likely scenario, which was define as the best representation of reality and the one chosen by UPS. Starting with CpPAP, which represents the cost for each package delivered at a UPS location. On table 6, this value was set to $CpPAP_{k1}$ for urban Lisbon and $CpPAP_{k2}$ for South shore of Tejo's River area, accordingly to the prices used in Spain. Nevertheless, it is essential to assess the impact of changes in this value to overall costs, as displayed on table 17.

Table 17- Sensitivity Analysis on the parameter cost per package delivered at UAP location

	Cost per Package delivered at UAP location (CpPAP)									
Total Cost	**-26%**	**UAPs**	**-13%**	**UAPs**	**Original**	**UAPs**	**13%**	**UAPs**	**26%**	**UAPs**
Lisbon Area	75684	13	76111	13	76538	13	76965	13	77392	13
Urban/Suburban areas	92244	20	92725	20	93207	20	93689	20	94170	20
South shore of Tejo's River	31315	15	31576	15	31838	15	32100	15	32361	15
Total	199242	**48**	200412	**48**	201583	**48**	202753	**48**	203923	**48**
Difference %	**-1.16%**	**0%**	**-0.58%**	**0%**			**0.58%**	**0%**	**1.16%**	**0%**
Difference to Original	**-2341**	**0**	**-1170**	**0**			**1170**	**0**	**2341**	**0**

In Table 17 it can be seen in the midsection is defined the standard cost and number of UAP locations, considering UPS network optimization and requirements, exhibit in table 10. Afterwards, CpPAP is increased or reduced in segments of 13% of the original value, and there is performed an assessment on the impact of such variations to total costs and number of UAP sites. This variation was discussed with the company in terms of what would be considered a feasible variation of cost per package delivered at UAP locations. The first range of +/- 13% was specified by UPS as a more likely deviation of CpPAP from original value. On the other hand, UPS also wanted to evaluate the potential impact of a higher deviation and thus, the second range is defined as $CpPAP_{original}$ +/- 26%. Looking at the last two lines from table 16 it is possible to find the differences compared to the original central column, for both total costs and UAP locations. The same structure frame is adopted for tables 17, 18 and 19, although the range of percentage variation of each parameter depends on what UPS finds more appropriate.

Cost-wise and number of UAP locations, the behavior is the same, both for CpPAP increments and reduction, with a maximum variation around 2341 units of measure (um) and 0 UAP sites. These results imply that parameter cost per package delivered at UAP location has no impact in UPS network configuration for a variation of 26%, both under and above the original value of CpPAP, since the number of UAP locations remains exactly the same for the three different areas of Lisbon. On the other hand, the same 26% variation represents a cost fluctuation of 2341 um, which is a 1,16% variation against the original scenario, making cost per package delivered at UAP location a robust parameter.

The second parameter to be assessed is cost per stop at UAP location (CpSAP), which is the highest absolute cost value when evaluating UAP operation. In this case, and according to UPS, it is performed a variation of about 10% in both ways around the original scenario and also a comparison against an increase of 20% of CpSAP as portrayed in table 18. The variation of 20% is only considered to cost increase because the scenario of such a reduction is considered to be infeasible.

Table 18- Sensitivity Analysis on the parameter cost per stop at UAP

	Cost per Stop at UAP location (CpSAP)							
Total Cost	**-10%**	**UAPs**	**Original**	**UAPs**	**10%**	**UAPs**	**20%**	**UAPs**
Lisbon Area	73473	14	76538	13	79526	13	82021	10
Urban/Suburban areas	89156	23	93207	20	94257	14	96602	13
South shore of Tejo's River	29995	16	31838	15	33669	15	35370	15
Total	192623	**53**	201583	**48**	207453	**42**	213993	**38**
Difference %	**-4.44%**	**10%**			**2.91%**	**-12.50%**	**6.16%**	**-20.83%**
Difference to Original	**-8960**	**5**			**5870**	**-6**	**12411**	**-10**

Considering Table 18 it becomes clear that a 10% variation on the parameter CpSAP has different effects on total cost and number of UAP locations. In this case, it is evident that total cost is more sensitive to cost per stop at UAP location reduction, even though the number of UAP locations has a higher variation for CpSAP increment. Another relevant fact worth mention is that a 10% variation around original scenario will have a higher impact in the number of UAP locations for urban and suburban areas. However, when a 20% increase is performed in cost per stop at UAP location, the scenario changes and the most affected region in terms of UAP locations is Lisbon area. On a different note, the most robust region in terms of UAP locations is South shore of Tejo's River, which keeps 15 locations regardless of the 20% increase and only adds 1 site for a 10% decrease in CpSAP.

The robustness of this parameter in South shore of Tejo's River is due to the fact that cost per stop for standard delivery is very high in this area, as displayed in table 4 for outside service provider 2. Thus, even with substantial increments on cost per stop at UAP location, the gap to standard delivery cost per stop is still considerable.

The final variable to be assessed is CAP, standing for the fee paid at the UPS store for each package delivered at UAP location. As depicted in table 19, a variation of 10% around the original values would result in a difference of 0,72% in total costs, for both cost reduction and increase. On the right column of table 19 it shows that a 20% increment in CAP, would impact a reduction of a single UAP location, while variations of 10% would not have any influence in the number of UAP sites. Similar to parameter cost per package delivered at UAP location, portrayed in table 17, parameter CAP is also very robust.

Table 19- Sensitivity analysis for fee per package delivered at UAP location CAP

	UAP store fee per Package delivered at UAP location (CAP)							
Total Cost	**-10%**	**UAPs**	**Original**	**UAPs**	**10%**	**UAPs**	**20%**	**UAPs**
Lisbon Area	75958	13	76538	13	77117	13	77697	13
Urban/Suburban areas	92605	20	93207	20	93809	20	93866	19
South shore of Tejo's River	31565	15	31838	15	32111	15	32384	15
Total	200128	**48**	201583	**48**	203037	**48**	203947	**47**
Difference %	**-0.72%**	**0%**			**0.72%**	**0%**	**1.17%**	**-2.08%**
Difference to Original	**-1455**	**0**			**1455**	**0**	**2364**	**-1**

In sum, after evaluating potential cost variations, a reduction in CpPAP, CpSAP and CAP around 10% would result in higher total cost variation than a 10% increase. In a different perspective, it is also clear that the number of UAP locations is more sensitive to cost increase and cost per stop at UAP location has the biggest weight in both total costs and number of UAP locations. Considering both the results obtained with optimization network formulation and sensitivity analysis, further sections will be focusing on conclusions and some recommendations.

6. Conclusions and Future Work

The boom of e-commerce is undeniable in modern world and companies have been adjusting their supply chain business model, in order to cope with that. Since e-commerce does not operate traditional physical stores, there is the need to create an additional transportation service closer to end customer. Thus, last-mile logistics has been increasing its importance in organizations that operate e-commerce driven supply chains. Last-mile logistics brings specific challenges to companies, namely the need for an efficient management of unattended deliveries and reverse logistics. Therefore, e-commerce is forcing companies to evolve their traditional supply chains, particularly focusing in transportation optimization, but also operating high service level, essential to e-commerce demanding customers.

The current thesis focuses in a supply chain network operator and freight forwarder UPS, which is facing the challenges described previously, due to increasing e-commerce. Up to this moment, UPS business model was based on centralized hubs in Lisbon and Porto that would make daily deliveries. Seeking for transportation cost optimization and service level improvements, UPS was looking for opportunities to redesign the current logistics network. This thesis arises from this need and intends to study different scenarios based on volume forecasts, that could result in the implementation of a second layer of distribution centers, closer to end customers and operated by local business stores. On a second phase, after assessing the redesign of UPS logistics network, the purpose of this thesis was to support the decision for the UAP locations, based on strict requirements, such as distance to customers and operating hours.

For better understanding of UPS operation, the first chapters intended to give a broader perspective of this company global operation, as well as a drilldown to UPS Portugal supply chain activities. To give solid support to this work assessment, literature review envisioned to describe several Location-Routing Problems (LRP), in order to implement a solution that could be a good fit for UPS Access Point network design.

An extended comprehension of UPS logistics operations, followed by a deep understanding on the parcel's delivery market, allowed the implementation of forecasting for the years of 2018, 2019 and 2020. Based on that, a multi-scenario approach toke place, considering three different scenarios based on failed delivery attempts: Optimistic scenario contemplates the case where there are less failed attempts to deliver the packages; Most likely scenario captures what it is most likely to occur, based on the forecasts; At last, Pessimist scenario describes the potential impact of higher failed delivery attempts.

The next step was to evaluate the different scenarios and for that purpose a mathematical formulation was developed and ran through Microsoft Excel. The so-called optimization was tested and validated by UPS logistics team and finally was able to produce some results. The potential for savings would include a mixed solution with current procedures for some Zip codes and UAP locations in others, with special interest in South shore of Tejo's River, where the cost for failed deliveries is high, due to bigger travelling distances.

Once the mathematical model is run to produce future results, using forecast premises that are always subject to uncertainty, as well as setup assumptions, which serve the purpose of problem´s simplification, there is the need to assess the robustness of the results obtained. Thus, a sensitivity analysis was performed on the parameters related with the UPS Access Point activities, which relate to more uncertainty, since there is no current background for Portuguese data. After assessing the results of sensitivity analysis, it can be concluded that results are robust around original parameters values. Nevertheless, it is also clear that parameter CpSAP is the one with higher impact in total costs, but specially in the number of UAP locations.

Considering the improved network, it is clear that results achieved show substantial improvements, especially with potential savings ranging from 14,5% to 16,1% for overall costs regarding the scenario of a single UAP location per Zip code, when costs are lower than standard UPS solution as exhibit in table 11. The cost to fulfil UPS requirements for customer distance to UAP location, would suggest a reduction on savings from 15,3% to 11,6%, accounting for 8530 um as displayed in table 15.

Acting accordingly to UPS standards for continuous improvement there are several opportunities that could be considered in the future. On a first note, the model should be extended to the city of Porto, in order to have a broader study for the implementation of UPS Access Point network. Secondly, new request for quotation (RFQ) should be performed, in order to bring more OSP. Once transportation costs have such a critical role on UPS business model, the company could look for OSPs with specialization in certain delivery areas, which can lead to efficiency improvements and cost reduction. Still related to cost optimization as referred in section 8, it is recommended that the implementation of UPS Access Point network in South shore of Tejo's River takes place with significant savings potential. On top of that, further analysis should be conducted in order to access the operational costs and economic viability of UAP locations setup around the airport area. Finally, with the boom of e-commerce it could be interesting not only to understand weather it could be a competitive advantage for UPS to implement its American business model, with its own UPS branded stores, closer to urban centers, but also whether UPS should start considering the implementation of sustainable measures, like owning an electrical fleet that could lead to substantial operational cost's reduction, as well as tax benefits for decreasing pollution.

In conclusion, regardless of potential future improvements, the expectations behind this work lead to a contribution concerning a real case in the parcel's delivery industry, providing a solid tool for UPS decision of UAP implementation in Portugal.

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Appendices

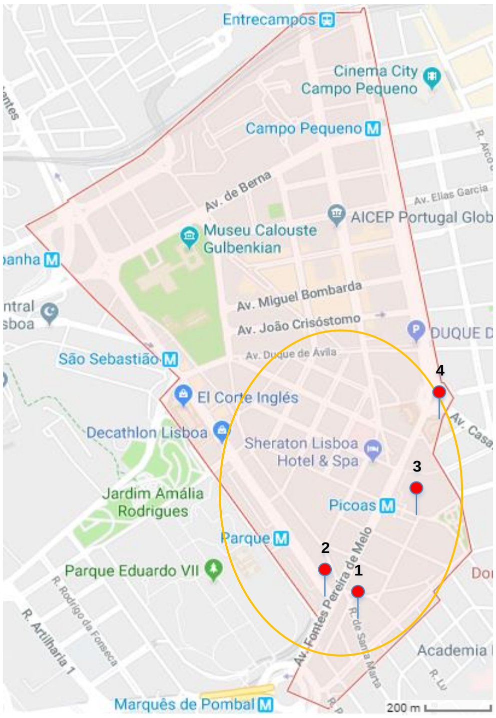
Appendix A: UPS potential Access Point locations for Lisbon Urban area

Appendix A1- Suggested number of UPS Dropoff locations and competition positioning for Zip code 1050-Campo Pequeno/Picoas

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	1	2	1	0

Potential UAP locations: 1- Papelaria do Andaluz. Address: R. de Santa Marta 28, 1050-121 Lisboa; 2- Gabi. Address: Av. António Augusto de Aguiar 1, 1050 Lisboa; 3- Papelaria São Marcos Lda. Address: R. Sousa Martins 35, 1050-129 Lisboa; 4- Livraria Almedina. Address: Praça Duque de Saldanha 1, 1050-094 Lisboa.

Appendix A2- Potential UPS Access Point locations for Zip code 1050-Campo Pequeno/Picoas



Appendix A3- Suggested number of UPS Dropoff locations and competition positioning for Zip code 1070-Praça de Espanha/Campolide

	ups	chronopost	DHL	GLS
Number Dropoff Locations	1	3	1	0

Potential UAP locations: 1- Papelaria Dona Revista. Address: R. de Campolide, 45B 1070-026 Lisboa; 2- Aqualis. Address: R. Dom Carlos de Mascarenhas, 76B 1070-216 Lisboa; 3- Jogaja. Address: Av. Eng. D. Pacheco (Amoreiras Shop.Center, LJ.1025) 1070 - 103 Lisboa.

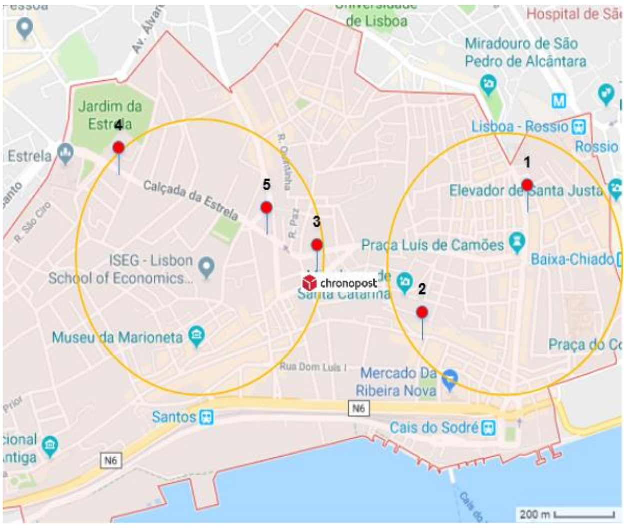
Appendix A4- Potential UPS Access Point locations for Zip code 1070-Praça de Espanha/Campolide

Appendix A5- Suggested number of UPS Dropoff locations and competition positioning for Zip code 1200-Santos/Cais do Sodré

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	2	1	2	2

Potential UAP locations: 1- Tabacaria Olimpica. Address: R. da Misericórdia, 73 1200-189 Lisboa; 2- Tabacaria Julia. Address: R. de S.Paulo, 111 1200 - 427 Lisboa; 3- Papelaria Planeta. Address: R.Poço dos Negros, 82-84 1200 - 341 Lisboa; 4- Papelaria Madeira. Address: Calcada da Estrela, 219-2211200 - 663 Lisboa; 5- Clínica Chip7. Address: Calçada da Estrela, 23 25 1200-109 Lisboa.

Appendix A6- Potential UPS Access Point locations for Zip code 1200-Santos/Cais do Sodré

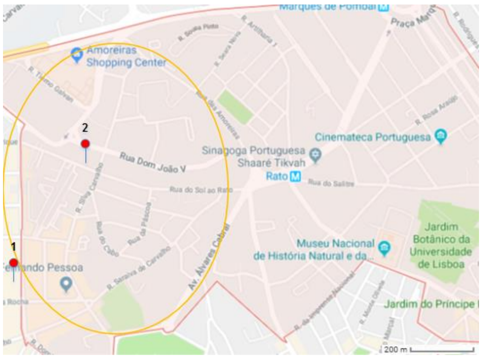


Appendix A7- Suggested UPS locations & competition positioning for Zip code 1250-Marquês de Pombal

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	1	1	0	0

Potential UAP locations: 1- Note!. Address: Rua Ferreira Borges, nº 82 A, Campo de Ourique, 1350-127 Lisboa; 2- Estrela de Ourique. Address: R. Campo de Ourique, 24D 1250-096 Lisboa.

Appendix A8- Potential UPS Access Point locations for Zip code 1250-Rato/Marquês de Pombal



Appendix A9- Suggested UPS Dropoff locations and competition positioning for Zip code 1300-Ajuda

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	1	2	3	1

Potential UAP locations: 1- Tabacaria Dail. Address: R. Guarda-Jóias, 32A 1300-294 Lisboa; 2- Cantinho Azul. Address: Calçada da Ajuda,91 LJ-3 1300 - 007 Lisboa; 3- Papelaria Josefina Costa. Address: LG.do Rio Seco, 20 1300 - 496 Lisboa.

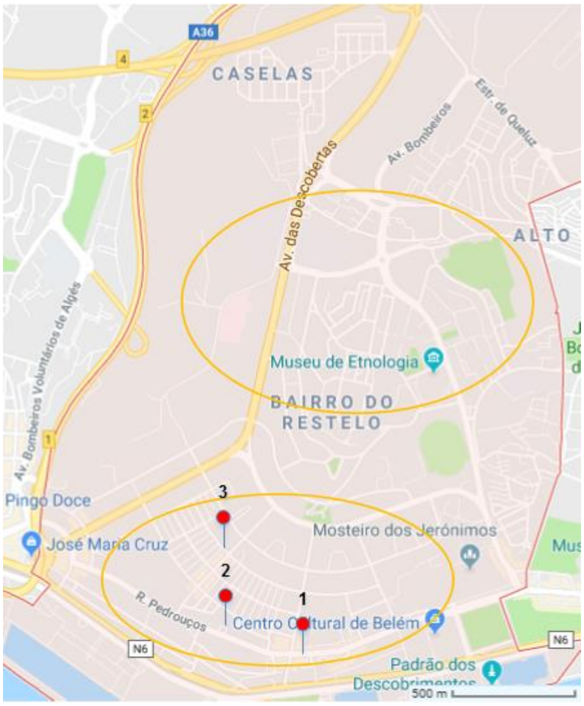
Appendix A10- Potential UPS Access Point locations for Zip code 1300-Ajuda

Appendix A11- Suggested number of UPS Dropoff locations and competition positioning for Zip code 1400-Restelo

	ups	chronopost	DHL	GLS
Number Dropoff Locations	1	0	0	2

Potential UAP locations: 1- Tabacaria Verdanis. Address: R. Bartolomeu Dias,166 1400 - 038 Lisboa; 2- Casa Elmar. Address: R. De Pedrouços, 61-B 1400 - 285 Lisboa; 3- Pastelaria O Careca. Address: R. Duarte Pacheco Pereira, 11D 1400-139 Lisboa.

Appendix A12- Potential UPS Access Point locations for Zip code 1400-Restelo



Appendix A13- Suggested number of UPS Dropoff locations and competition positioning for 1495-Cruz Quebrada/Algés

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	1	1	1	0

Potential UAP locations:1- Jackpot. Address: Av. Combatentes da Grande Guerra, 68 1495-034 Algés; 2- Papelaria Nequim. Address: R. Dr. Manuel de Arriaga, 35 1495-088 Algés; 3- Press Store. Address: Av. Bombeiros Voluntários de Algés, 70B 1495-023 Algés.

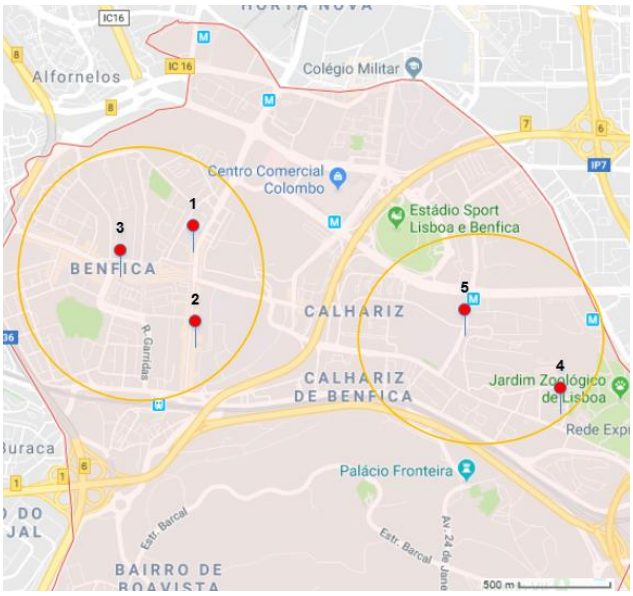
Appendix A14- Potential UPS Access Point locations for Zip code 1495-Cruz Quebrada/Algés

Appendix A15- Suggested number of UPS Dropoff locations and competition positioning for 1500-Sete Rios/Benfica

	ups	chronopost	DHL	GLS
Number Dropoff Locations	2	3	2	1

Potential UAP locations:1- Papelaria Lusitano. Address: Av. do Uruguai 9, 1500-086 Lisboa; 2- Tabacaria Afrodite. Address: Av. Gomes Pereira 41B, 1500-328 Lisboa; 3- Casa da Sorte. Address: Estr. de Benfica 719F 1500-088 Lisboa; 4- Tabacaria Cerqueira. Address: R. Padre Francisco Álvares 5A, 1500-478 Lisboa; 5- Pastelaria Moinho Dourado. Address: R. Maj. Neutel de Abreu, LT-20 LJB 1500-411 Lisboa.

Appendix A16- Potential UPS Access Point locations for Zip code 1500-Sete Rios/Benfica

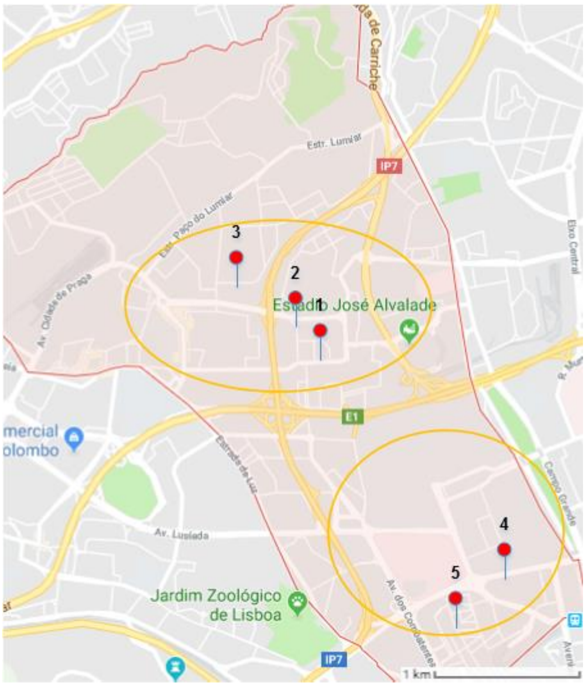


Appendix A17- Suggested number of UPS Dropoff locations and competition positioning for 1600-Campo Grande/Telheiras

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	2	4	3	1

Potential UAP locations: 1- Papelaria Flor de Lotus. Address: R.Prof.Francisco Gentil, Ed.E1,Lj.2b, 1600-625 Lisboa; 2- Azul Giesta. Address: R. Prof. João Barreira 27, 1600-535 Lisboa; 3- Tabak. Address: Av. Nações Unidas, C.C. Continente, LJ-23 1600-528 Lisboa; 4- Copycenter. Address: Av. das Forças Armadas 63, 1600-311 Lisboa; 5- Tabacaria Castor. Address: R. Beneficência 197A, 1600-019 Lisboa.

Appendix A18- Potential UPS Access Point locations for Zip code 1500-Sete Rios/Benfica



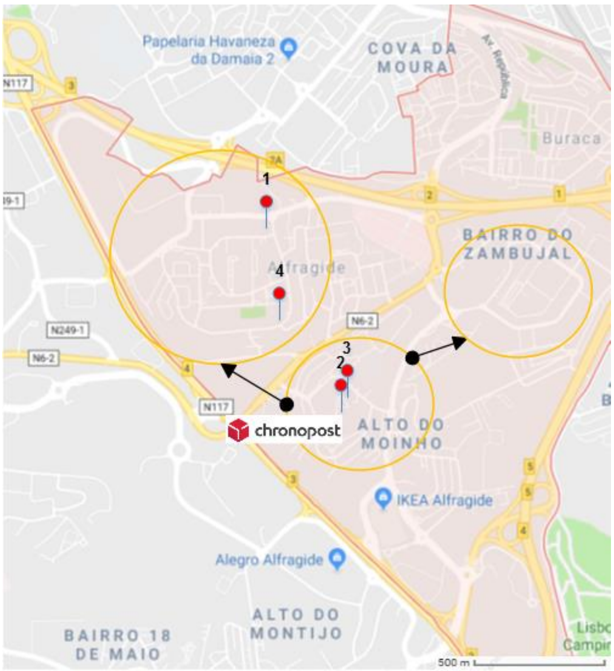
Appendix B: UPS potential Access Point locations for Other Urban/Suburban areas

Appendix B1- Suggested number of UPS Dropoff locations and competition positioning for Zip code 2610-Alfragide

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	1	1	0	0

Potential UAP locations: 1- Majorali-Papelaria. Address: Av. Qta. Grande 4-A, 159, 2610 Alfragide; 2- Papelaria Inicio. Address: Rua Pinheiro Borges, Centro Comercial de Alfragide loja 2, Sul, 2610-140 Alfragide; 3- Artes e Devaneios. Address: R. Pinheiro Borges 22, 2610-140 Alfragide; 4- Galeria. Address: R. Alberto Aldim 3B, 2610-123 Alfragide.

Appendix B2- Potential UPS Access Point locations for Zip code 2610-Alfragide

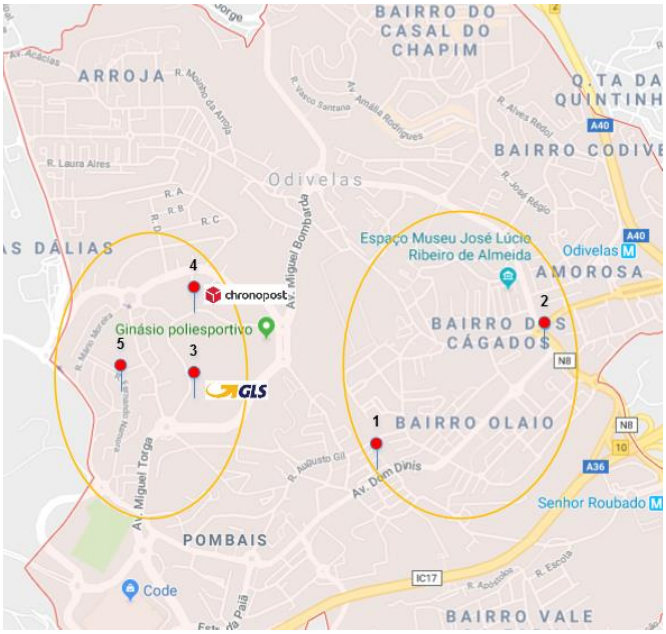


Appendix B3- Suggested number of UPS Dropoff locations and competition positioning for Zip code 2675-Odivelas

	ups	chronopost	DHL	GLS
Number Dropoff Locations	2	3	2	1

Potential UAP locations: 1- Papelaria Santiago. Address: Av. Dom Dinis 88A, 2675-329 Odivelas; 2- Nossa Senhora De Monserrate-papelaria. Address: R. Guilherme Gomes Fernandes 31, 2674-488 Odivelas; 3- TUTIPAPER II - Papelaria Tabacaria. Address: R. Pulido Valente 6, 2675-672 Odivelas; 4- JP Comunicações. Address: R. Pulido Valente, 16 LJ 1 ColinasCruzeiro — 2675-672 Odivelas; 5- Papelaria/Tabacaria Pássaro de Papel. Address: R. Fernando Namora 26, 2675-489 Odivelas.

Appendix B4- Potential UPS Access Point locations for Zip code 2675-Odivelas

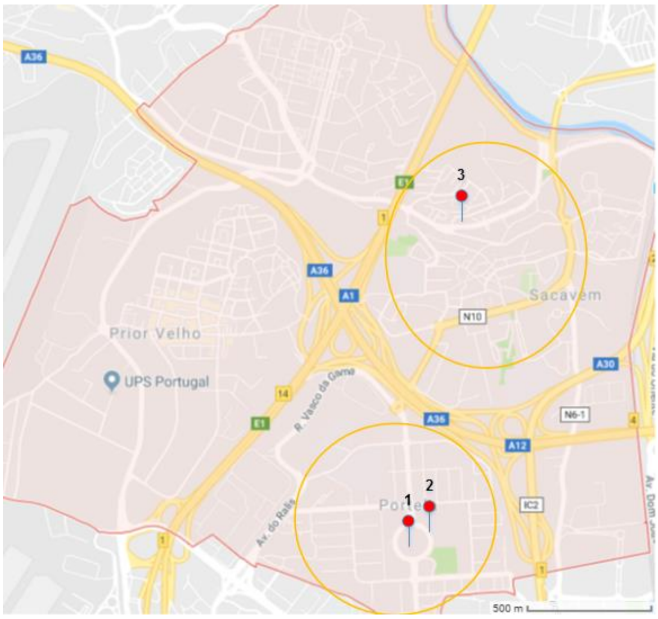


Appendix B5- Suggested number of UPS Dropoff locations and competition positioning for Zip code 2685-Portela/Sacavém

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	2	3	2	1

Potential UAP locations: 1- Papelaria 33. Address: C.Com. Portela, LJ 33 R/C, 2685 - 223 Portela; 2- Picar o Ponto Papelaria. Address: Rot. Nuno Rodrigues Santos, 2- C.Com. Portela, LJ 13 1ºP, 2685 - 223 Portela; 3- Papelaria Águia de Ouro. Address: R. Auta da Palma Carlos 27, 2685-025 Sacavém.

Appendix B6- Potential UPS Access Point locations for Zip 2685-Portela/Sacavém

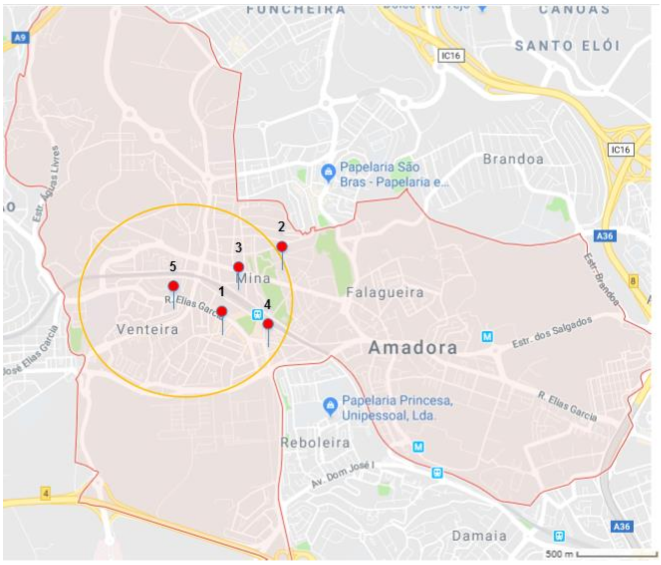


Appendix B7- Suggested number of UPS Dropoff locations and competition positioning for Zip code 2700-Amadora

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	1	3	1	1

Potential UAP locations: 1- Papelaria Jardim da Venteira. Address: R. 1º de Dezembro 18B, 2700-671 Amadora; 2- Papelaria Quatro Folhas. Address: Av. Gen. Humberto Delgado 32B, 2700-559 Amadora; 3- Mina da Sorte. Address: Av. Cardoso Lopes 31B, 2700-160 Amadora; 4- Pastelaria Pigalle. Address: R. Alfredo Keil 20/24, 2700-036 Amadora; 5- Titulos a Solta. Address: R. António Sardinha 21A, 2700-084 Amadora.

Appendix B8- Potential UPS Access Point locations for Zip 2700-Amadora



Appendix B9- Suggested number of UPS Dropoff locations and competition positioning for Zip code 2735-Cacém

	ups	chronopost	DHL	GLS
Number Dropoff Locations	2	3	2	1

Potential UAP locations: 1- Papelaria Tabacaria. Address: Praceta Fraternidade Universal 7, 2735-073 Sintra; 2- Isa Papelaria. Address: Av. dos Bons Amigos 55, 2735 Cacém; 3- Tabacaria Ana e Jorge. Address: R. Prof. António Joaquim Neves 30, 2735-233 Agualva-Cacém; 4- M. Gabriela-Tabacaria e Papelaria. Address: R. Sebastião Antunes, 2A, 2735-265 Agualva-Cacém.

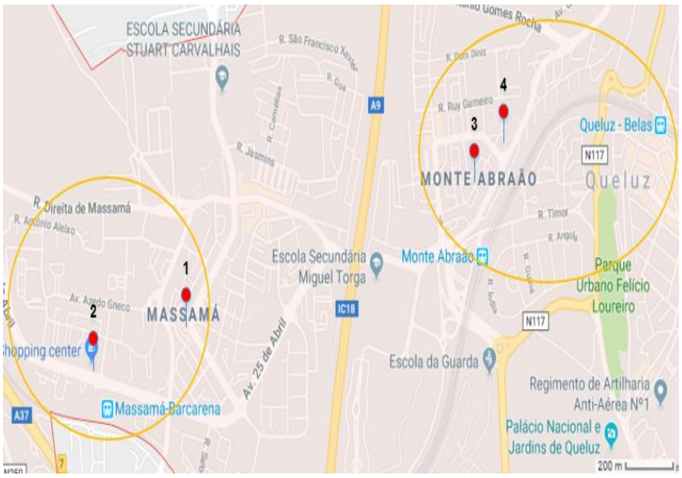
Appendix B10- Potential UPS Access Point locations for Zip 2735-Cacém

Appendix B11- Suggested number of UPS Dropoff locations and competition positioning for Zip code 2745-Queluz/Massamá

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	2	5	4	3

Potential UAP locations: 1- ColorSpot. Address: Rotunda Dra. Laura Aires, 2745-758 Queluz; 2- Shopping Center. Address: Av. 25 de Abril 60, 2745-733 Queluz; 3- Tabacaria O Monte. Address: R. Prof. Dr. Virgílio Machado 17, 2745-232 Queluz; 4- Lojas Carmil. Address: Av. Luís de Camões 10, 2745 Queluz.

Appendix B12- Potential UPS Access Point locations for Zip 2745-Queluz/Massamá



Appendix C: UPS potential Access Point locations for South shore of Tejo's River

Appendix C1- Suggested number of UPS Dropoff locations and competition positioning for Zip code 2800-Almada

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	2	2	1	1

Potential UAP locations: 1- Tabacaria. Address: Av. Dom Afonso Henriques, 30 B 2800-174 Almada; 2- Tabacaria Dianalmada. Address: R. Cmte. António Feio, 40 2800-304 Almada; 3- Tabacaria Borges. Address: R. Cândido dos Reis, 130 C 2800-269 Almada; 4- Premium Press. Address: Av. Dom Nuno Álvares Pereira, 24 2800-169 Almada; 5- Papelaria Novalmada. Address: R. Torcato José Clavine, 9-A * Pragal 2800 - 710 Almada.

Appendix C2- Potential UPS Access Point locations for Zip 2800-Almada

Appendix C3- Suggested number of UPS Dropoff locations and competition positioning for Zip code 2830-Barreiro

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	1	4	1	1

Potential UAP locations: 1- Papelaria Carol. Address: R. Dr. Manuel Pacheco Nobre 96, 2830-085 Barreiro; 2- Tabacaria Royal. Address: R. Bartolomeu Dias, 2A 2830-040 Barreiro; 3- Papelaria Laurinda. Address: R. Dr. Manuel Pacheco Nobre, 40-A 2830 - 080 Barreiro; 4- Toto Bonfim. Address: R. Miguel Bombarda, 303 2830-276 Barreiro; 5- Magnolândia. Address: R. 5 de Outubro, 6A 2830-036 Barreiro.

Appendix C4- Potential UPS Access Point locations for Zip 2830-Barreiro

Appendix C5- Suggested number of UPS Dropoff locations and competition positioning for Zip code 2840-Seixal

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	1	3	2	1

Potential UAP locations: 1- Papelaria Nova Era. Address: Av. José Afonso, 10A 2840-735 Seixal; 2- Zona Press. Address: Alam. Bombeiros Voluntários,12-A 2840 - 395 Seixal; 3- Papelaria Lila. Address: R. Mécia Mouzinho de Albuquerque 5, 2840-430 Arrentela; 4- Farmácia Alves Velho. Address: R. Luís de Camões 27B, 2840-402 Arrentela.

Appendix C6- Potential UPS Access Point locations for Zip 2840-Seixal

Appendix C7- Suggested number of UPS Dropoff locations and competition positioning for Zip code 2855-Corroios

	UPS	chronopost	DHL	GLS
Number Dropoff Locations	2	2	1	1

Potential UAP locations: 1- Tabacaria Rosy. Address: R. Cidade Lourenço Marques, 14 2855 - 134 Corroios; 2- Papelaria Catimar. Address: R. Niza,11 (C.C.Pierrot, LJ-17) * Vale Milhacos 2855 - 429 Corroios; 3- Papelaria Paraíso. Address: Av. Fábrica da Pólvora, 27 * Vale Milhacos 2855 - 382 Corroios; 4- Papelaria Rouxinol. Address: Av. Luís de Camões,10 LJ-28 * Miratejo 2855 - 121 Corroios; 5- Papelaria Só Tomás. Address: R. Casa do Povo,13 2855 - 110 Corroios. Site 5 has particular interest for its central location in APNID area, but also because it is situated near Casa do Povo train station.

Appendix C8- Potential UPS Access Point locations for Zip 2855-Corroios

Appendix C9- Suggested number of UPS Dropoff locations and competition positioning for Zip code 2870-Montijo

	ups	chronopost	DHL
Number Dropoff Locations	2	4	2

Potential UAP locations: 1- Papelaria Salvador. Address: Av. Luís de Camões 29, 2870-163 Montijo; 2- Papelaria Madeira. Address: Joaquim nº95, R. José Joaquim Marques, 2870-348 Lanhas; 3- Livraria Anjo. Address: R. João Pedro Iça 57, 2870-113 Montijo; 4- Papelaria Kraft. Address: Praça Concórdia 194, 2870-471 Montijo; 5- Decathlon Montijo. Address: Av. das Portas da Cidade, 2870-448 Montijo; 6- Casinha dos Sonhos Atelier. Address: Praça Paz Centro Comercial Bela Vista Loja 8 ,2870-861, 2870-861 Montijo.

Appendix C10- Potential UPS Access Point locations for Zip 2870-Montijo

Appendix C11- Suggested number of UPS Dropoff locations and competition positioning for Zip code 2890-Alcochete

	UPS	chronopost	DHL
Number Dropoff Locations	1	1	1

Potential UAP locations: 1-MEB Papelaria. Address: R. Escola Secundária, 228, 2890-066 Alcochete; 2- Papelaria Viktorias. Address: R. Comendador Estevão de Oliveira 36, 2890-154 Alcochete; 3- Papelaria Pina. Address: R. João Facco Viana, 1, 2890-080 Alcochete;

Appendix C12- Potential UPS Access Point locations for Zip 2890-Alcochete