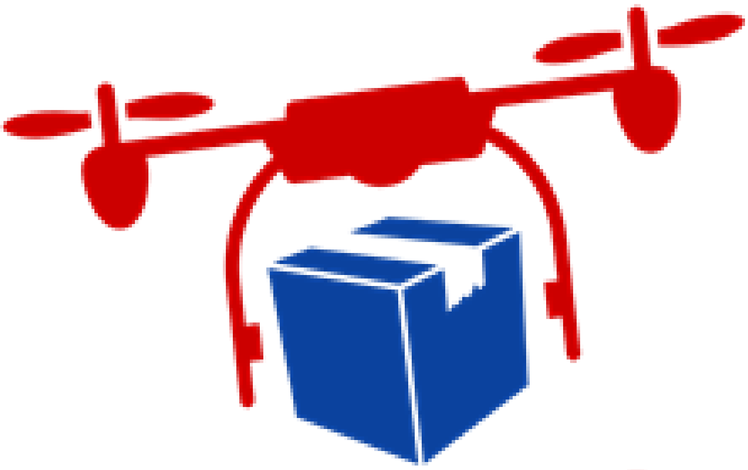
Double degree Master thesis project

"Analysis of possible Scenarios for application of Unmanned Aerial Vehicles (UAVs) for Business-to-Consumer (B2C) parcel delivery operations of food and non-food products within urban areas"



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Abstract

Since Internet has been invented, online product purchase has become a more popular activity and with it demand for Business-to-Consumer (B2C) parcel delivery has grown as well (Hesse and Rodrigue, 2004). This increasing traffic flow of commercial vehicles together with a strong urbanisation phenomenon has caused severe effects on urban areas. For instance, it has been observed a worsening of the overall mobility level, an increasing environmental pollution and lower level of safety of urban space (ALICE and ERTRAC, 2015; Pataki et al., 2007; Angel et al., 2005). This condition has forced freight logistics and distribution industry to make progress in order to carry on performing operations and one of the latest solutions to improve urban mobility concerns the potential application of Unmanned Aerial Vehicles (UAVs) as vehicles for B2C parcel deliveries.

By means of an analytical process of information collected from different sources (desk research, conferences, in-depth interviews of professional and academics), this explorative research project has tried to achieve three main goals. First, it aims to assess if UAVs present suitable technological features to perform urban B2C parcel deliveries. Then, it attempts to develop possible freight logistics and distribution network designs for UAVs. Finally, identification of possible regulation concerning application of UAVs for commercial operations in urban areas and the relative role assumed by regulative authorities in performing this normative process.

Keywords: UAVs, freight logistics and distribution network, urban area, freight transport regulation.

Executive summary

This master thesis project will present a set of possible different scenarios for the application of autonomous Unmanned Aerial Vehicles (UAVs) in the freight logistics and distribution industry with general suggestions concerning possible norms and rules for this specific commercial application of these unmanned autonomous vehicles in urban context. Fundamental concepts of this research project, which have been subjects of a detailed investigation, are UAVs' technological features, Supply Chain management and freight transport regulation in urban areas. The student has conducted the investigation: he has performed a desk research activity, has attended two conferences (one about logistics and the other concerning commercial applications of UAVs) and has conducted eleven personal-in depth interviews of academics and professionals whose expertise relate with the one or more of the research concepts.

All the information, which the investigatory activity has provided, have been integrated and then analysed. The outcome of this analytic process can be divided in three micro areas:

- An assessment of the importance of specific UAVs' technological features and relative importance in defining the feasibility to implement these vehicle category in a commercial context like the one of B2C parcel delivery in urban areas

- Development of possible freight logistics and distribution network designs based on different assumptions concerning level of endurance offered by UAVs' propulsion system, product categories (food and non-food) and model of ICT infrastructure supporting operations

- Identification of the possible UAVs' features that will need to be regulated, the possible role played by regulative authorities (both higher-level regulative authorities and urban authorities) and which features are going to norm respectively

However, this master thesis project presents a few limitations, as it has not been possible to include in the investigation other elements related to the topic of B2C parcel delivery in urban areas by means of UAVs. For instance, it has not been given focus to assess the possible effects that an application of these unmanned autonomous vehicles can have at level of insurances, labour policy and safeguard. In addition, the formulation of the algorithms that are going to be set up in UAVs' autonomous control system poses an ethical problem, as it would be necessary to identify who will be accountable for this subject.

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1. Research background

Freight logistics and distribution industry has undergone several significant changes during last decades that have transformed it in one the major business in the world. According to Zukin and Mcguire (2004), phenomenon of mass consumption, which has arisen from the North American society culture and after World War II, it has spread across other industrialised countries (e.g. Canada, Western Europe, Japan) and then in developing countries, has been a major factor of these changes. The system of mass consumption can be defined as a social organisation where the majority of individuals benefits of a larger and wider range of consumer goods thanks to a higher productivity level achieved firstly through mass production and then mass customisation phenomena (Matsuyama, 2002). This greater availability of goods has contributed to the birth of the social phenomenon of consumeristic life style, in which people buy and consume large quantities of goods. This phenomenon, combined with the development of new technologies (e.g. Internet), has favoured the implementation of deregulation and liberalisation economic policies that have reduced trading barriers with consequent birth of modern global economy (Hesse and Rodrigue, 2004; Held et al., 1999).

Since its appearance in the mid-1990s, Internet has had a significant effect on freight logistics and distribution industry. Actually, goods availability and accessibility have enormously increased thanks to the appearance of online shops and E-market platforms (Hesse and Rodrigue, 2004).
Online shopping has steadily increased its popularity worldwide and the community of online shoppers has acquired more purchasing power. This new situation of the market has enhanced the pressure on business organisations, as now they have to face a more complex and demand driven market that asks for timely conduct of freight logistics and distribution operations (Cyr et al., 2004; Van Slyke et al., 2004; Visser and Lanzendorf, 2004; Visser and Nemoto, 2003; Kinsey and Senauer, 1996). Therefore, business organisations have had to adapt in order to keep running commercial operations and the result has been to observe Supply Chain fragmentation phenomenon. Here, business organisations have started to delegate freight logistics and distribution activities to independent specialised logistics service providers, which are highly skilled in managing and performing freight transport and return operations thanks to a more effective and efficient use of Information and Communication Technologies (ICT) solutions (Visser and Lanzendorf, 2003).
Figure 1 gives an idea of the differences that has happened in the last years inside the logistics of freight.

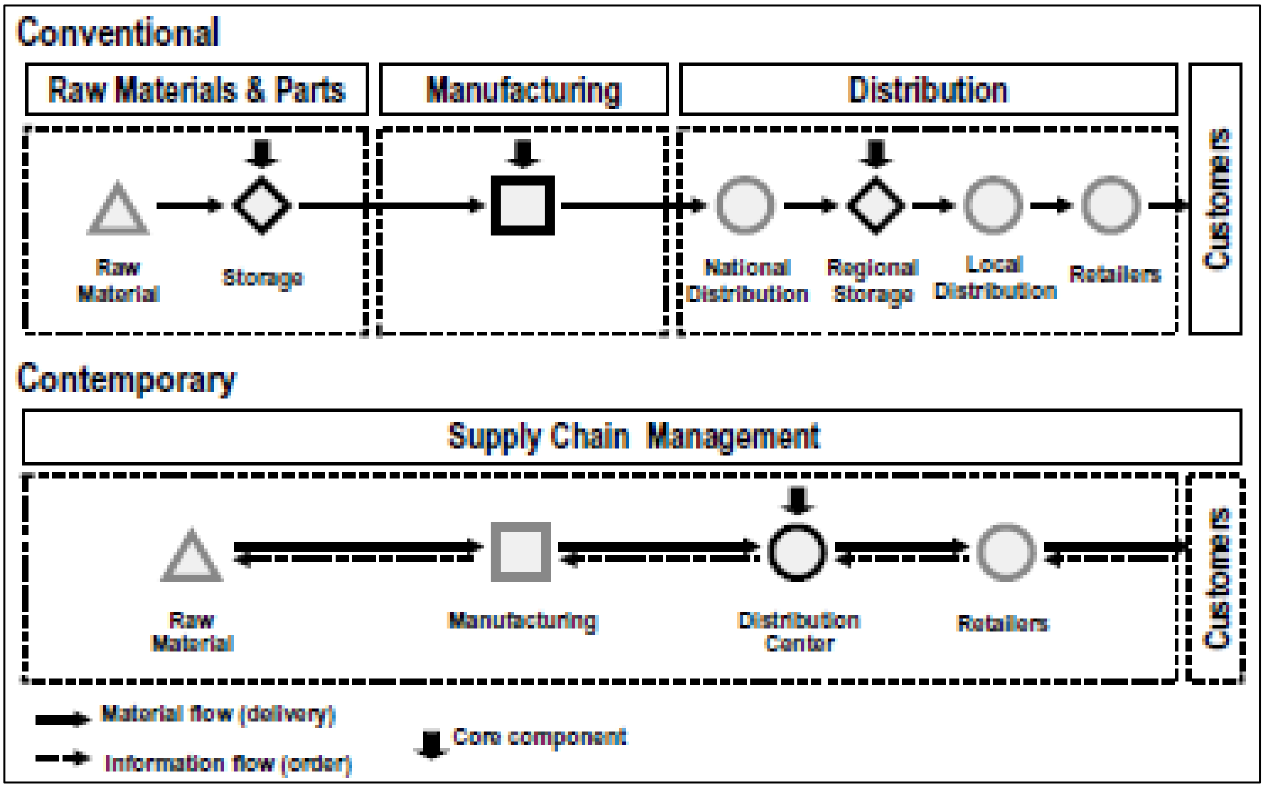

Figure 1: Conventional versuss contemporary arrangement of freight flows (source: Hesse and Rodrigue, 2004)

These specialised freight logistics and distribution service providers can exploit both Business-to-Business (B2B) and Business-to-Consumer (B2C) operations. Overall, from 2008 (year of the global financial crisis) up to 2014, the average growth rate of logistics and distribution industry has been 15 percent, corresponding to a market capitalisation of $960 billion (World Economic Forum White Paper, 2016). As customers have become more and more familiar and inclined to shop online, demand for B2C parcel delivery service has considerably increased. As example, data presented by Doherty and Ellis-Chadwick (2010) and Dablanc (2007) show that in 2010 the UK online and catalogue retail industry served 26.9 million of customers (corresponding to almost half of national population) and in France between 2000-2005 online shopping reached 25 per cent (corresponding to €8,7 billions) of the overall mail order modes respectively.

1.1 Problem definition

The increasing online shopping activity has caused an enhancement of the use of B2C parcel delivery service. This phenomenon has been a challenge for freight logistics and distribution providers, as the quantity of freight transport operations in urban areas has significantly risen compared to the pre-Internet era. Furthermore, other factors are challenging freight logistics and distribution industry, such as the same urbanisation process. Actually, since 2008, the number of people living in urban areas has become larger than non-rural population and this trend does not seem to stop, as forecasts indicate that 70 per cent of world population is expected to live in urban areas within 2050 (Seto and Shepherd, 2009). This increasing density of people living in limited geographical areas is characterised by an intense demand of urban-land use. This shrinkage of space is an obstacle for freight logistics and distribution providers, as they need space for facilities and infrastructures in order to conduct optimally commercial operations (Angel et al., 2005; Hesse and

Rodrigue, 2004). Moreover, despite online shopping has become popular among customers, it cannot be considered a perfect substitute of traditional shopping trips yet, which means that trips generated by online and traditional shopping occur simultaneously within the same space. The consequence is an increases of urban traffic volume with negative effects on urban areas in terms of mobility and environmental pollution as well (Pataki et al., 2007; Boschma and Weltevreden, 2005; Visser and Nemoto, 2003). Moreover, if more vehicles move along the same urban road infrastructures, there is also a higher probability that either accidents or fatalities can occur (Pataki et al., 2007; Hesse and Rodrigue, 2004).

Large part of freight logistics and distribution industry is currently using fossil fuels-based vehicles. This event, combined with the aforementioned scarce level of consolidation and integration of Supply Chains, has a strong impact on urban areas. Data presented by ALICE and ERTRAC (2015) and Visser and Lanzendorf (2004) depict a situation within the EU-area where freight transport accounts for 25 per cent of the overall urban activities related to CO_2 emissions and between 30 and 50 per cent of other pollutants (e.g. Particulate Matter (PM) and Nitrogen Oxide (NO)) caused by transport activities respectively. Moreover, freight transport is also the main cause of noise pollution within urban areas.

The environmental impact of freight logistics and distribution industry can be even stronger. According to Zhang and Zhang (2013), other than design and implementation of freight logistics and distribution networks that allow an effective and efficient conduct of B2C parcel delivery operations, nowadays a proper management of reverse Supply Chain flows is also required, as risk of parcel delivery failure (corresponding to missed end-customer’s parcel collection) can occur during normal conduct of operations. Furthermore, society and regulative authorities have started making pressure in order to promote practices focused on recycling and reuse of goods in order to minimise waste production. An optimal management of reverse Supply Chain can make possible to avoid an increase of Supply Chain costs and environmental pollution as well.

Coordination and integration of forward and reverse Supply Chain operations is even more important in case perishable products are involved, as this product category needs the implementation of temperature maintenance, control and monitoring measures in order to either avoid or minimise commercial damages, which can potentially lead to a public health issue in the worst-case scenario (Rodrigue, 2014). Therefore, freight logistics and distribution providers have to implement specific measures at the different Supply Chain stages (e.g. storage, transport) that usually require higher capital investments and rise of operational costs (Kuo and Chen, 2010).

All the aforementioned factors play a role in making urban freight logistics and distribution one of the most complex, delicate and problematic commercial activities. Therefore, a question raises spontaneously: which actions can the today’s freight logistics and distribution industry implement in order to tackle these issues concerning freight logistics and distribution operations in urban areas?

Looking at many web pages of different mass media channels, Unmanned Aerial Vehicles (UAVs), also commonly known as drones, seem to be a possible solution.

UAVs are flying devices that do not need presence of pilot on-board and nowadays they are commonly considered a must-have among high-tech gadgets. For instance, GoPro has recently launched its new product named “Karma”: a drone that promises to transform radically the experience of taking photos and videos with GoPro cameras (gopro.com). Nevertheless, UAVs are machines that can exploit commercial operations, as shown by the positive outcomes of their implementation in Precision Agriculture (Stehr, 2015; Zhang and Kovacs, 2012). One of the latest

ideas for a commercial application of UAVs concerns B2C parcel delivery operations in urban areas. Actually, several mass media (bbc.com; fortune.com) have reported that a few big players in the E-retailing industry (e.g. Amazon, Alibaba), food retailing (e.g. Wal-Mart) and fast-food industry (e.g. Domino's Pizza) are currently doing research and tests for exploitation of UAVs as vehicles for B2C parcel deliveries. Despite these first tests have offered promising results, several issues of various nature need to be addressed and solved before the application of these unmanned vehicles can become real.
First, it is necessary to define a clear framework of regulations for commercial use of UAVs. In the USA, the Federal Aviation Administration (FAA), which is the legal authority appointed to take decisions about aeronautical matters, has started only few years ago to address the topic of commercial applications of UAVs, but the pace of its decision making process is not sufficient to deal with the business organisations' high demand for UAVs (nytimes.com). In the scenario where UAVs will perform B2C parcel deliveries in urban areas, besides governmental organisations, local public authorities will probably participate in the regulative decision-making process as well. Actually, despite modern freight logistics and distribution networks are developed with the aim to operate efficiently and effectively, ALICE and ERTRAC (2015) have argued that every urban area owns certain peculiarities in terms of available infrastructures and configuration of urban structure that can be obstacles for conduct of logistics and distribution operations. Therefore, in accordance with the City Logistics concept (whose goal is provision of optimal freight logistics and distribution service while minimising negative effects on other urban traffic flows and urban environment), collaboration, coordination and partnership between public authorities and professionals are considered extremely recommended (Cranic et al., 2004).

Beyond regulative aspects, other issues concerning UAVs need attention as well. In order to perform B2C parcel deliveries, it is necessary that UAVs own certain technological features that ensure reliability, effectiveness and efficiency of these unmanned vehicles in performing operations. As Susini (2014), Dalamagkidis et al. (2008) and Elias (2012) have argued in their respective documents, UAVs present still a few defects, especially concerning ICT measures for UAVs control that compromise operational reliability and by consequence increase the probability of malfunctions that can cause UAVs' crashes against either people or properties. Concern also rises when it is time to discuss about socio-political implications related to the use of UAVs. For instance, they could be equipped with devices that do not respect privacy safeguard policies (Cavoukian, 2012; Elias, 2012) or they could heavily affect freight logistics and distribution industry in terms of labour safeguard (Rao et al., 2016).

1.2 Research objective

Aim of this master thesis project is to depict possible scenarios and their relative benefits and limits of the application of Unmanned Aerial Vehicles (UAVs) in Business-to-Consumer (B2C) parcel delivery networks for perishable and non-perishable products within European urban areas.

1.3 Research questions

The next two sub-sections will represent the general research question and the specific research questions respectively for this master thesis project. The general research question is the interrogative form of the research objective. From it, the student has deducted the specific research questions, whose answers should give a solution to the general research question.

1.3.1 General research question

Compared with the current situation of B2C parcel delivery industry, what can be the scenarios and their relative benefits and limits of the application of UAVs in B2C parcel delivery networks for perishable and non-perishable products within European urban areas?

1.3.2 Specific research questions

1. Which kinds of technological features, advantages and/or limits can UAVs display in performing B2C parcel delivery operations compared with the current road vehicles performing B2C parcel deliveries in urban context?

2. With respect to current practices adopted by freight logistics and distribution providers, how would the Supply Chain management features (e.g. online ordering management, inventory management, forward and reverse SC management and costs management) be in the event UAVs perform B2C parcel delivery operations?

3. What physical and/or ICT infrastructures will UAVs need in order to perform B2C parcel delivery operations compared with the ones that freight logistics and distribution providers are currently using?

4. What kinds of norms would be included in a regulative framework for UAVs performing B2C parcel delivery operations in European urban areas? What would be the regulative authorities involved in this normative process of UAVs?

2. Key concepts and Definitions

This section contains the most meaningful concepts and theories for this research project. A few concepts can need to undergo an operationalisation process in order to assume a proper definition that fits with the subject under analysis. Therefore, it could be possible that the definitions present in this document differ from eventual other available ones.

2.1 UAV and UAS

Within this study, the term Unmanned Aerial Vehicle (UAV) will assume the meaning that the International Civil Aviation Organisation (ICAO) applies to define an autonomous aircraft:

“An unmanned aircraft that does not allow pilot intervention in the management of the flight.”

(Cir, I. C. A. O., 2011)

However, despite focus goes on autonomous UAVs for conduct of B2C parcel delivery operations, presence of UAV operator will also be included, as this professional figure could still perform certain tasks, such as UAVs monitoring during operations and maintenance. Moreover, it is necessary to consider where UAV operator is going perform his tasks. Therefore, Ground Control Station (GCS) are another feature than need attention. The system formed by UAV, UAV operator and GCS will be named Unmanned Aerial System (UAS) and ICAO defines it as:

"An aircraft and its associated elements which are operated with no pilot on board."

(Cir, I. C. A. O., 2011)

2.2 Supply Chain

"A Supply Chain consists of all parties involved, directly or indirectly, in fulfilling a customer request"

(Chopra and Meindl, 2016).

These are the words that this master thesis project adopts to define what is a Supply Chain. In order to offer a more extensive explanation of this definition, a Supply Chain consists of a dynamic system, where a constant flow of information, operations, products and funds occurs. The process starts with a customer's request and the final objective is to satisfy such request and simultaneously achieve maximization of the overall value that is generated along the entire Supply Chain. The context where this definition is applied is the freight logistics and distribution industry, with a specific focus on B2C parcel delivery service.

2.3 Urban Area

As argued by Salvatore et al. (2005), a worldwide-standardised definition of what is an urban area and its spatial characterisation are still missing. Actually, the same authors report:

"because of national differences in the characteristics that distinguish urban from rural areas, the distinction between urban and rural population is not amenable to a single definition that would be applicable to all countries"

(UN, 1998 cited in Salvatore et al., 2005)

Moreover, the body of the literature contains other examples about the inconsistency in discriminating what is urban from what is rural. For instance, a "rural area" can be defined as location presenting "not urban" characteristics (UN, 1998 and 2004 ac cited in Salvatore et al., 2005). Instead, according to Weeks (2010), the large improvements in mobility infrastructure and communication technologies of last decades have enlarged the group of people that can participate actively in urban life, which makes difficult to apply a clear cut between urban and rural environments. Moreover, the master student believes that an application of administrative

boundaries for human settlements (e.g. cities, town and villages) based on a quantitative threshold would result meaningless because of the great variability of these values across nations.
To achieve a standardised definition of urban area, this research project adopts the reasoning of Weeks (2010) that uses the term "urban" to refer to a place-based characteristic incorporating several criteria, such as population size, population density and socio-economic features. A suitable definition that respect vision of Weeks (2010) is the one offered by a document of the Organisation for Economic Co-operation and Development (OECD). Actually, it identifies urban areas as functional economic units giving the advantage to overcome all the limitations caused by the different national administrative definitions that prevent cross-country comparisons. This definition allows to identify 828 cities in the European continent that be categorised in six classes (S, M, L, XL, XXL and Global city) based on the urban centre size, which has to include at least 50,000 inhabitants (OECD, 2012).

2.4 Urban mobility and environmental policies

Urbanisation has been a key phenomenon of 21st century that freight logistics and distribution activity has favoured and sustained. However, modern urban areas have become a challenging environment for freight logistics and distribution providers, as mass-customised production and increasing success of online shopping have drastically modified the traditional production and distribution practices. Nowadays, freight logistics and distribution industry has to deal with unsuitable and/or insufficient urban infrastructures that can have the side effects to either cause various inefficiencies or reduce safety in the conduct of operations. Therefore, the need to develop and design proper plans aiming to favour mobility within urban space. To define such concept, this study will adopt the definition of City Logistics:

"*…the process for totally optimizing the logistics and transport activities by private companies with the support of advanced information systems in urban areas considering the traffic environment, its congestion, safety and energy savings within the framework of a market economy."*

(Taniguchi et al., 2001b as cited in Tseng et al., 2005)

By the way, energy savings need a further explanation, as they still result undefined. This research project will attempt to address energy savings from two perspectives: aim would be to offer an idea about possible savings in terms of costs and pollution that could be achieved through the application of UAVs for B2C parcel delivery operations.

3. Literature review about Unmanned Aerial Vehicles (UAVs)

Chapters 3 contains all the information that the student has been able to collect about UAVs during the desk research activity. Specifically, this chapter will provide a brief presentation of UAVs and then it will offer the information concerning fundamental UAVs' technological features that could have a role in defining the ability to perform B2C parcel delivery operations in urban areas of these unmanned aircrafts.

3.1 Unmanned Aerial Vehicles (UAVs): brief introduction

Unmanned Aerial Vehicles (UAVs), most commonly known with the name “drones”, are a peculiar class of aircrafts that do not need presence of a pilot on-board. Actually, the general design of UAVs does not include any cockpit, which is the compartment where pilot usually exploits control functions on conventional aircrafts. The US Navy developed the first UAVs prototypes during World War I (WWI) and first official UAVs’ missions were performed during the Vietnam War (Susini, 2014; Elias, 2012). However, interest for commercial applications of UAVs has risen only in recent times. Nowadays, different industries have started to benefit from the use UAVs, such as agri-businesses for Precision Agriculture (PA) operations, movie industry and rescue departments for post natural disaster missions as well (Kückelhaus, 2014). However, all the current UAVs commercial applications need an UAV operator that pilots the vehicle by means of remotely control devices. Instead, freight logistics and distribution industry is interested in the application of autonomous UAVs for exploitation of B2C parcel delivery operations (ALICE and ERTRAC, 2015; DeGarmo, 2004) that could cause drastic changes on both conduct of freight logistics and distribution operations and urban areas. Therefore, it is important to address the attention on certain UAVs’ technological features whose understanding can help to assess the real potential of such unmanned vehicles in performing B2C parcel deliveries in urban context.

3.2 UAVs’ technological features

Other than the basic distinction between military and civil categories, UAVs can differ along a series of technical features that can affect UAVs’ ability to accomplish a specific task. Therefore, in the next sub-paragraphs, the master student has focused the investigation activity on a few technological features that can be appropriate to assess the possible most suitable UAVs’ configurations for B2C parcel delivery operations.

3.2.1. UAVs’ propellers design

Propellers are the first elements that can be considered as discriminating criteria for UAVs. According to part of the literature (Custers, 2016; Kückelhaus, 2014; Kenzo, 2007), UAVs present two main models of propellers: fixed-wing and rotors. If the former are very similar to traditional airplanes, the latter include a various sub-classes due to a large variety of propellers in terms of number and configuration. A few examples are conventional single rotors, bi-rotors, quadrotors, hexacopters and coaxial helicopters.

UAVs belonging to the rotors categories present the extremely interesting and useful property of Vertical Take-Off and Landing (VTOL) ability. Aircrafts that own VTOL ability are able to conduct flight operations even in presence of relative scarcity of space, which is a common condition of urban areas. Instead, fixed wing UAVs do not own propellers for VTOL manoeuvres, which is technical condition that force them to take-off and land only in presence of large spaces. Moreover, rotors’ propellers design gives the additional ability to sustain high g-forces during flight operations that increases rotors’ performance in terms of speed control and manoeuvrability compared to fixed-wing UAVs with consequent safer and more effective conduct of operations even in environments presenting several externalities and relatively scarce space, as modern cities. However, rotors cannot usually reach speeds that are comparable to fixed-wing designs, as these last ones have a better airworthiness values that give the opportunity to achieve higher flight speed and flight efficiency as well (Kückelhaus, 2014; Sevcik and Oh, 2008; Kenzo, 2007).

3.2.2 Vehicle's size

UAVs can be categorised based on size. This feature can be considered a significant criterion, as it is commonly applied to classify commercial vehicles for freight transport because size can have a direct relation in defining the vehicle's transport capacity (Hosseini and Shirani, 2011; Keebler and Plank, 2009). However, if on one hand large size allows enhancing the payload transport capacity, on the other it makes the vehicle's structure bulkier. Heavier vehicles need propulsion systems enough powerful to generate the necessary power to move the vehicle and the eventual payload, which can implies higher requirements of propulsion system components, independently from the power source (e.g. either traditional internal combustion or electric batteries). Actually, according to part of the literature (Rao et al., 2016; Cummings et al., 2007), significant increase of size would affect the core engineering components of propulsion systems: batteries, transmission and main rotor mast. Therefore, transport capacity cannot be the only variable to take into account during the decision making process in order to perform B2C parcel delivery operations. Actually, operational costs can be significantly affected by wrong decisions concerning payload's weight, as it would be possible to experience considerable increase of energy consumption level needed to perform the task (Bendea et al., 2008).

3.2.3 UAV's propulsion systems

Decisions concerning propulsion systems require specific attention, as they can affect several aspects. For instance, the match between propulsion system and level of airworthiness of the vehicle design can influence performance in terms of speed, which in turns affects distance and time span of operations (Kenzo, 2007). Despite it is usually considered a positive characteristic for the conduct of freight transport, speed cannot be the only criterion on which vehicle choice can be based. As example, traffic laws impose norms on commercial and private vehicles that have to be respected, such as the common speed limits. Other factors can play a role in defining choices on propulsion system. For instance, endurance has a significant influence in defining the level of operational efficiency and effectiveness of commercial vehicles. Specifically, concerning flying vehicles like UAVs, the term endurance refers to the ability of an aircraft to spend a certain time span in cruising flight modality. Current UAVs models present a wide range of endurance, going from hobby models of low endurance up to military UAVs that can operate up to 48 hours. Moreover, other aspects can affect flight endurance, such as flight altitude. Actually, air is more rarefied at higher height and this operational condition causes higher energy consumption in order to sustain flight (Oettershagen et al., 2015). However, large differences in endurance performance are mainly due to the propulsion system technology (Sanli and Gunlu, 2016). With the exclusion of military UAVs, which are equipped with jet engines, the majority of civil UAVs owns electric propulsion systems. Part of the literature (Kückelhaus, 2014; Tie and Tan, 2013) has argued that the electric option in the form of either Hybrid Electric (HE) or All Electric (AE) technologies is expected to provide opportunities to achieve improvements in economic and environmental performance compared with traditional Internal Combustion Engines (ICEs). Actually, propulsion systems can account for a large part (up to 90 per cent sometimes) of power consumption (Schafrot et al., 2008) and in case of ICEs, there is also the negative side effect of price fluctuation of fossil fuels (Sanli and Gunlu, 2016). By the way, between the two electric options previously mentioned, AE propulsion systems are expected to either offer a better control or even achieve a reduction of operational costs, as their components do not present sophisticated design and structural complexity, which reduces the sensitivity to usury with consequent potential maintenance costs savings. Further reason to adopt AE propulsion systems is the release of the new guidelines concerning urban mobility promoted by European regulative authorities, as mentioned during the European Logistics Platform conference held in Brussels (B), whose main goal is to achieve both economically and environmentally sustainable urban mobility in the next future.

However, before UAVs can perform B2C parcel deliveries in urban context, it is necessary to solve a few technical gaps of electric propulsion systems, as they risk compromising the possibility of a large-scale application of UAVs for this specific commercial activity. The batteries that are currently integrated in civil UAVs represent a severe issue, as they have a limited endurance that is generally considered insufficient for B2C parcel delivery operations. Possible measure to increase UAVs' endurance could be to allocate a larger space for batteries setup, but it could affect negatively vehicle's design (less compact design) and it could cause significant weight increase with consequent risk of overcoming the optimal trade-off longer endurance-more weight thanks to implementation of additional batteries, since they have shown high sensitivity to payload's weight variation. This sensitivity to weight variation is a critical issue, as it can limit control and optimisation of operations (Sanli and Gunlu, 2016; Tie and Tan, 2013).

3.2.4 UAVs' autonomous control system

The portfolio of possible control systems for UAVs is formed by three options: remotely, semi-autonomous and autonomous control systems. They differ for the degree of human intervention that is needed in order to control UAV during the conduct of operations.

As it has occurred in various manufacturing processes across multiple industries, freight logistics and distribution providers have also exhibited interest for development and implementation of solutions that enhance the level of automatization of operations. Actually, part of the literature (Kückelhaus, 2014; Barrientos et al., 2009) agrees on saying that automatization is a powerful tool, as it make possible to standardise and manage optimally operations in order to achieve control and reduction of costs. Another reason in support of higher degree of automatization, which does not relate directly to exploitation of economic benefits, is the potential higher level of reliability and by consequence safety of operations. Actually, part of the literature (Oh and Piegl, 2013; Weibel, 2005; DeGarmo, 2004) has argued that human factor is the main cause of UAVs accidents and crashes and this phenomenon has been observed in case of operations in both Visual Line Of Sight (VLOS) and internal vision remotely controlled missions. Actually, UAV's operator has limited field view and remotely control modality tends to exacerbate the human beings' physiological gap in reaction time. Difficulties would increase exponentially if operator has to control an UAV in remote modality in order to perform a parcel delivery to a location that may need Beyond Visual Line OF Sight (BVLOS) flight within an urban environment rich of externalities.

Autonomous control systems include a flight computer and navigation computer as core components and these two devices need a constant flow of data to perform their functions. Data are supplied by other components that interact with either the external environment or the interior of the UAV. These devise are named sensors (topic of the next sub-section of this chapter). They collect and supply data to computers that will execute a processing activity to generate a set of inputs that will lead UAV to perform specific manoeuvres that would aim to perform operations optimally based on the situation faced by the UAV at a specific time (Kurnaz et al., 2009).

The decision-making process of autonomous control systems usually works based on algorithms. Certain algorithms classes (e.g. Artificial Neural Network, Genetic Algorithm) have provided positive outcomes during empirical test (Uhrmann and Schulte, 2011; Allaire et al., 2008; Dalamagkidis et al., 2008). A reason that can explain the successful adoption of algorithms is their peculiar property to incorporate and replicate part of human behaviour in a standardised fashion, although they are self-contained systematic sets of mathematical operations. According to the same authors, algorithms can enable the machine to interact actively with the external environment by recognising surrounding circumstances and consequently adopt the most suitable actions in order to achieve a specific predetermined goal. However, gaps in algorithms formulation have to be covered in order to achieve a minimum sufficient level of reliability and safety for conduct of B2C parcel delivery operations, as results achieved in conduct of UAVs' autonomous flights are extremely limited (Kurnaz et al., 2009). Significant gap of today's algorithms is their marginal ability to include uncertainty in their formulation and difficulty to include such variable is due to potential presence of dynamic externalities. These last ones slow down significantly the computational process, as they cannot be fully predicted to the contrary of static externalities (Goerzen et al., 2010; Rysdyk et al., 2003). The possibility to include almost completely uncertainty in the algorithm formulation would be extremely beneficial, as it would help to perform and maintain optimal control of operations in real world scenarios, where several externalities move independently across three special dimensions. Actually, until now, the level in algorithms formulation has enabled to achieve linear waypoints navigation management, which has been considered a too basic level for an autonomous conduct of operations in urban areas (Goerzen et al., 2010; Rysdyk, 2003). Moreover, certain aspects of operations (e.g. take-off and landing) need more research in order to make UAVs able to perform them in reliable and effective way (Kurnaz et al., 2009).

3.3.5 Sensors

As mentioned in the 3.3.1 sub-section, autonomous control systems need a flow of different data in order to perform reliably and effectively their task. Sensors are the technological pieces of equipment that have to accomplish such task. The market offers a great variety of sensors in terms of type, quality and quantity of data that can be gathered and then supplied to autonomous control system. These technical differences lead to different operational performances and costs vary as well (Kurnaz et al., 2009). Therefore, it would be interesting to assess which sensors would be the most suitable in order to accomplish a specific task.

Due to the relevant role of sensors in making the entire system operative, it would be a mistake to exclude them from the R&D process. Actually, as suggested by a few authors (Custers, 2016; Sanli and Gunlu, 2016; Bizon, 2011b-2011c), preferences for certain sensors can cause significant variations of weight (with consequent repercussion on propulsion system) and components architecture as well. Moreover, it can be reasonable to expect that autonomous UAVs will need additional (and maybe more sophisticated) sensors than the ones commonly present in present in remotely controlled UAVs, such as accelerometers and altimeters that detect and control flight altitude and speed variations respectively. Instead, gyroscope ensure balance control (Kurnaz et al., 2009). Then, cameras are one of the most common devices implemented on UAVs and they vary in dimensions and functionalities, as they can collect and transmit more than photos and videos. For instance, there are camera models able to sense temperature or measure distances of an object thanks to optical sensors or laser integrated in their frame.

3.3.6 UAVs Information and Communication Technologies (ICT)

As it occurs normally in road and air transport, where multitude vehicles move simultaneously across the same space, a similar situation can be expected in case autonomous UAVs will perform B2C parcel deliveries moving across urban air space. This event requires the setup of an ICT infrastructure that can ensure a reliable and effective management of UAVs for the entire conduct of operations. Transfer, integration and coordination of operations have to occur not only between a single UAV and its operator (remotely control case), but instead it has to occur between UAVs of the same fleet (as already happens for vans of a single fleet in managing parcel delivery operations) and between several fleets of autonomous UAVs as well. Aim of ICT infrastructures would be to ensure tracking-monitoring-control activity and increase trajectory management of these autonomous unmanned aircrafts as well. These conditions make possible to operate through a reliable system that can minimise possibility of accidents between UAV-UAV and UAVs-urban externalities (Oh and Piegl, 2013).
In the eventuality that operator either pilots UAV or monitors autonomous UAV' operations, he needs a dashboard to perform such activities. Frew and Brown (2009) have named it Ground Control Station (GCS). Despite the traditional hand-size controllers used to pilot single UAV, GCS could have a more elaborated configuration in case of autonomous UAVs performing B2C parcel delivery operations, as CGS would need to receive, integrate, process and transfer a large quantity of data in order to coordinate a fleet of autonomous UAVs. Moreover, CGS can be either mobile of fixed structures. The system formed by UAVs and the respective GCS has been named Unmanned Aerial System (UAS) and these elements have to be constant and effective communication (Frew and Brown, 2009).

Research in Information and Communication Technologies (ICTs) has made considerable progress in last years and this progress has partially favoured the application of UAVs in different market segments. Frew and Brown (2009) have proposed a few ICT infrastructures network models for a large-scale application of UAVs and they differ under several perspectives, such as coverage range and relative size of investment. Table 1 offers a brief overview of the respective advantages and downturns of the various ICT infrastructures network models that can either favour or prevent their implementation to support UAVs' B2C parcel delivery operations in urban context.
A considerable number of authors (Arnold and Zandbergen, 2011; Chao et al., 2010; Doitsidis et al., 2004; Rysdyk, 2003; Dufrene, 2003; Andrievsky and Fradkov, 2002) support the idea to use Global Positioning System (GPS) technology as ICT infrastructure for autonomous UAVs, as it is a well-known and free ICT infrastructure. However, they are also aware that GPS alone cannot ensure a sufficient reliability level for conduct of operations in complex environments like modern cities, as it presents certain gaps (e.g. sensitivity to environmental conditions with consequent signal disturbance) that prevent constant control of the vehicle. Therefore, it could be necessary to integrate an additional ICT infrastructure in order to create a reliable communications system for autonomous UAVs performing B2C parcel deliveries in urban areas.

Communication network model	Advantages	Downturns
Direct link	- Low level of complexity - Low investment	- Inability to sustain BVLOS communications in presence of physical obstacles (e.g. buildings)
Satellites network	- Vast coverage area for communications	- Delay link in communication - Relatively expensive investment (GPS excluded)
Cellular network	- Wide range of coverage areas for communications - Good performance in connectivity and data transfer - Long-term investment	- Need of consistent investments - Full potential if several subjects share common strategy - Once established, further modifications are expensive
Mashing network	- Relative expensive (but less than cellular network) - The flexible structure can offer different range of coverage areas for communications	- Communication nodes do not ensure effective centralisation and coordination of information - Demanding management of the structure

Table 1: explicative table of advantages and downturns of the different communication network models (source: Frew and Brown, 2009).

4. Literature review about Supply Chain

This section deals with the topic of Supply Chain network designs and relative managerial practices. Nowadays, literature concerning B2C parcel delivery networks operating by means of UAVs is extremely scarce. Therefore, the desk research will focus on gathering information about current distribution networks and relative managerial practices to perform B2C parcel delivery operations that are going to form the basis for an explorative investigation on this potential UAVs' specific commercial application.

4.1 General information about conventional Supply Chain for non-perishable products

During last decades, from a mere efficient and effective distribution of goods, Supply Chain concept has undergone a series of changes due to social-political and economic pressures and availability of new technologies that has increased the complexity of its structure. Mass production and Internet have been phenomena that have expressed profound effects on Supply Chains, as business organisations have had to either modify or change their network infrastructure and managerial practices in order to maintain good performances. Poor attention to these features has been suggested to potentially cause economic damages, such as operational costs increase and devaluation of brand value (Prahinski and Kocabasoglu, 2006; Tibben-Lembke and Rogers, 2002; Ferrer and Whybark, 2001). This new market conditions have favoured the appearance of a new type of Supply Chain that has steadily increased its role in the worldwide economy: E-Supply Chain.

Traditional Supply Chain is based on the "Brick and Mortar" concept and part of the literature (Chopra and Meindl, 2016; Park and Regan, 2004; Enarsson, 2002; Kaufman-Scarborough and Lindquist, 2002) argues that it hardly fits with current trends of global economy. Elements supporting this opinion are an intricate and rigid structure that forces products to pass through several steps (factory – central warehouse - local warehouse) and the involvement of a plurality of different and independent actors (suppliers, producers, distributors, retailers) that usually tend to pursuit personal strategies. Moreover, products can undergo same operations (e.g. handling, loading, de-loading, and transportation) for multiple times. The consequence is that products need a longer time span to reach end-consumers and the risk is to miss overall maximisation of Supply Chain performance as well (Chopra and Meindl, 2016; Ernarsson, 2002; Kaufman-Scarborough and Lindquist, 2002).

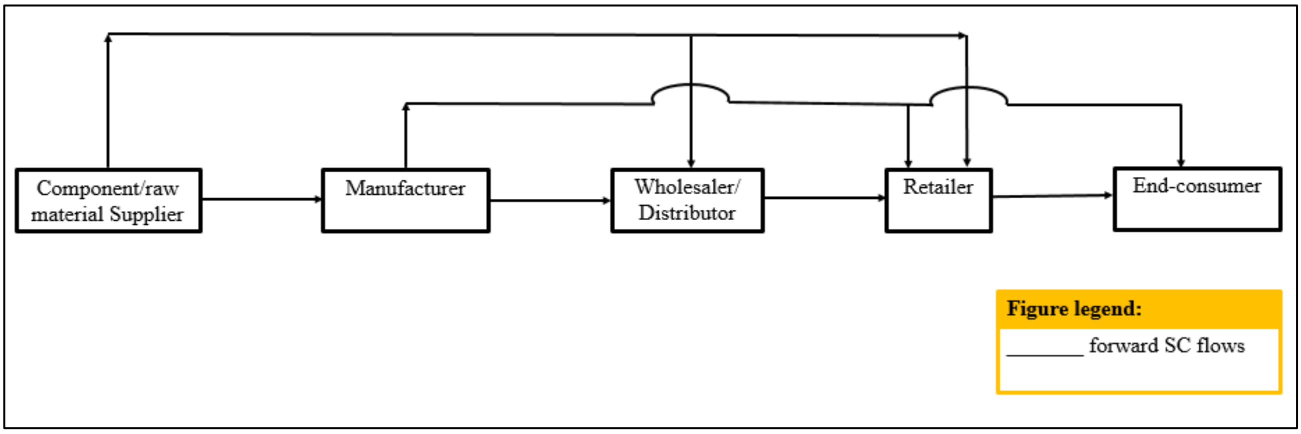

Figure 2: graphical representation of a traditional Supply Chain (or "Brick and Mortar system") without considering product reverse flows.

Instead, a general E-Supply Chain presents notable differences compared with "Brick and Mortar" system. Firstly, the lower number of actors involved in the chain. Platforms for online shopping (E-commerce and E-market places) have offered an easier and faster way to do product purchase, but this phenomenon has increased the pressure on business organisations, as end-consumers have started to expect shorter time span for parcel deliveries as well. According to a few authors (Boschma and Weltevreden, 2005; Pachè, 2001), risk of mismatching these expectations can lead end-consumers to judge the service as inefficient and unreliable, with consequent economic damage for business organisations. Furthermore, online shopping has been a major contributor of batch disintegration phenomenon, which is the trading, handling and transport of product batches of small size (sometimes even formed by single items) that can have different destinations. Batch disintegration combined with an articulated structure, like the one of traditional Supply Chain, would lower the customer service level, as order aggregation and coordination of information and operations would be extremely difficult and expensive to achieve (Patil and Divekar, 2014; Boschma and Weltevreden, 2005; Park and Regan, 2004). Among the changes that Supply Chains have undergone in order to adapt to the new market conditions caused by rise of online shopping, a significant event has been the appearance of the professional figure of third Logistics Service Providers (3LPs). Among producers and retailers it has spread the custom to manage only inbound flow of digital information (customers' orders) and outsource administrative and outbound logistics and distribution operations to these professionals in order to make Supply Chain shorter whilst ensuring optimal customer service level for online customers (Chopra and Meindl, 2016; Boschma and Weltevreden, 2005; Kaufman-Scarborough and Lindquist, 2002). Part of the literature (McKinnon and Tallam, 2003; Kaufman-Scarborough and Lindquist, 2002) has suggested that E-Supply Chains offer certain benefits, such as higher degree of flexibility in the configuration of the distribution network and time management of parcel delivery operations as well. However, efficiency and effectiveness can be achieved only through proper management and coordination of both information and operations flows (Johnson and Wang, 2002).

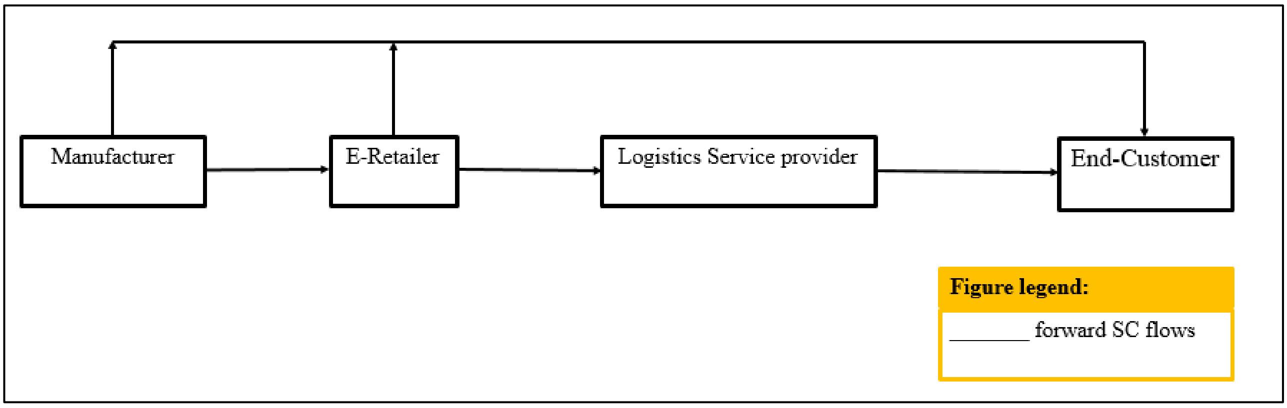

Figure 3: graphical representation of a general E-Supply Chain without considering product reverse flows

Figure 2 and Figure 3 are general representations of traditional Supply Chain and E-Supply Chain respectively that do not take into account possible differences due to certain factors. As example, product category is a significant factor that discriminates between Supply Chain for non-perishable products (also named conventional Supply Chain) and Supply Chain for perishable products (whose general characteristics are presented in the following sub-section 4.2).

4.2 General information about Supply Chain for perishable products

In order to market perishable products, freight logistics and service providers have to implement certain specific measures along the entire Supply Chain in terms of either distribution network infrastructures or managerial practices in order to ensure a proper management of this product category.

In general, a Supply Chain for perishable products is a system of logistics facilities and operations whose aim is to commercialise a specific class of goods that share the characteristic of perishability. It means that they have a higher sensitivity to both physical-environmental parameters (e.g. temperature, humidity, controlled atmosphere levels) and chemical parameters (e.g. pH, water activity) compared to non-perishable products. Classic examples of perishable products are fresh foods (e.g. meat, fish, dairy, fruit and vegetables), frozen foods, ready-made meals and even a few pharmaceuticals. However, especially in B2C parcel delivery operations, control and monitoring activities usually include temperature and/or humidity levels, as these are considered sufficient measures to ensure preservation of product quality and thus minimise risk of safety issues as well (Montanari, 2008; Punakivi et al., 2001).

Internet and the related phenomenon of online shopping has affected the trade of perishable products as well. Nowadays, other than traditional shopping at physical stores, customers have the opportunity to do grocery or order ready-made meals by means of online sale platforms in order to either collect the parcel later at the store or receive it directly at a specific address. This last option defines the E-grocery and ready-made meal delivery service.
It is interesting to notice that phenomenon of batch disintegration affects E-grocery and the effects can be even stronger than in Supply Chains for non-perishable products. Actually, besides the average weight of an E-grocery parcel is heavier than a conventional order placed on a retailer's online sale platform, several units of different items can form the order. Most important, despite the advantage to have large part of the products in packaged format, risk of cross contamination with potential raise of safety issue need to keep separate certain products (e.g. cooked and raw foods). Moreover, not all the perishable products have the same storage requirements, as some may require either refrigerated or frozen temperature during storage and transport operations. These events limit the possibility to exploit freight bundling, which favours a more efficient use of storage and transport capacity (Boschma and Weltevreden, 2005).

4.3 General information about reverse Supply Chain

For online sale of products that cannot be in digital format, B2C parcel delivery service is usually a necessary activity in order to enable end-customers to get in possession of the goods that have been purchased through online. However, product flows can also occur in a backward fashion, which means that products go from end-customers to online sellers. Part of the literature (Chopra and Meindl, 2016; Pokharel and Mutha, 2009; Castell et al., 2004; Ferrer and Ayres, 2000) has defined this circular product flows phenomenon as Closed-Loop Supply Chain (CLSC).
All reverse product flows occur because a failure has occurred during exploitation of B2C parcel delivery operations and they can occur for different reasons. For instance, Weltevreden (2008) has identified product category as a variable affecting returns rate. Then, there is always the risk that end-customer is not present at the time of operator delivers the parcel or end-consumer could initiate product returns procedures due to either damages or wrong content of the parcel caused by mistakes during transportation or order fulfilment respectively. Besides, there is also the eventuality that products enter reverse Supply Chain flows due to environmental policies that aim achieve waste reduction (e.g. recycling process). Based on this variety of different reasons, Krikke et al. (2003) have developed a classification of product returns that distinguishes between commercial returns, repairable returns, end-of-use returns and end-of-life returns.
All these eventualities, which cause product returns, force business organisations to implement certain necessary extra activities. Based on the information in de Brito (2003) and Fleischmann et al. (2000), Table 2 offers an overview of these processes and the types of Supply Chain costs that are involved.

Reverse Supply Chain Process:	Description:	Type of Supply Chain costs involved:
Product Acquisition	Retrieval of products back from the market	Transport costs ICT costs
Collection	Acquired products go to facilities where different processes are performed	Transport costs Facilities costs ICT costs
Sorting-Testing-Disposition	Process to identify best use product returns and/or of its components	Handling costs Inventory costs

Table 2: reverse Supply Chain processes with relative description and type of Supply Chain costs (source: de Brito (2003) and Fleichmann et al. (2000)).

The importance to achieve a proper management of reverse Supply Chain processes is explained by a part of the literature (Pokharel and Mutha, 2009; Janse, 2008; Wang et al., 2007; Prahinski and Kocabasoglu, 2006; Yalabik et al., 2005; Krikke et al., 2003; Ferrer and Whybark, 2001). Actually, they sustain that it is a necessary measure to either avoid significant raise or even exploit an eventual minimisation of operational costs. Otherwise, the same authors has warned about scarce attention to returns management, as it has been related to possible considerable increase of several costs features (e.g. transport, handling, physical facilities, inventory). Furthermore, returns management needs consistent investments in ICT infrastructures, since integration and coordination of reverse and forward products flows are highly recommended thanks to the opportunity to improve profit margins, which are usually quite compressed in today's freight logistics and distribution industry (Kocabasoglu et al., 2007; Mollenkopf and Closs, 2005; Ravi and Shankar, 2005; Yalabik et al., 2005). These potential profitability improvements come not only from accurate strategies of costs minimisation, but also from performing extra processes on product returns in order to exploit value recovery. Depending on the type of product return, value recovery can materialise in different ways, such as sale in original or alternative market (Verstrepen et al., 2007; de Brito, 2003; Fleischmann et al., 2000). Besides economic reasons, the body of the literature includes a few studies that argue about the significant role that regulative authorities (especially in the European Union) have in ether providing support or even defining norms and rules to perform returns management practices that business organisations have to fulfil and respect (Janse, 2008; Álvarez-Gil et al., 2007; Toffel, 2003).

4.4 Non-perishable products Supply Chain distribution network designs

Development of a logistics and distribution network is a complex decision-making process concerning how to manage facilities and operations of both forward and reverse Supply Chains under the influence of product category factor as well. These decisions have the power to affect differently the Supply Chain costs features (e.g. physical facilities, inventory, handling, transport and ICT costs). Therefore, structure of a freight distribution network owns a strategic value, as it can exercise an influence on the performance service level (Park and Regan, 2004; Enarsson, 2002).

Within the body of the literature, Chopra and Meindl (2016) offer a clear vision about six general freight distribution networks designs that can be more or less suitable for online commercialisation of either non-perishable or perishable products. Each of these designs own a few peculiarities that can have different implications at operational level. For instance, parcel reception modality can be either attended (end-customer or pickup point operator collects parcel at the time of delivery) or unattended (none parcel receiver at the time of delivery). This last option can be distinguished between two further categories: unsecured and secured parcel deliveries (McKinnon and Tallam, 2003). The same authors argue that, despite the benefit to lower the probability of parcel delivery failure, choice between one of these two unattended parcel reception modalities affects costs, as they require different investments on parcel protection systems.
The next sub-paragraphs are concise overviews about the structure and the relative Supply Chain costs features of these freight distribution network designs.

4.4.1 Manufacturer storage with direct shipping

This is a very common freight distribution network design adopted by E-retailers. The information flow originates from online customers, it passes through an intermediate step managed by E-retailer and it ends at one or more manufacturers. These last subjects use the information to perform a set of activities: orders assembling, loading and final parcel delivery. Nevertheless, nowadays it is common to observe a further information flow between manufacturers and freight logistics and distribution providers once customers' orders have been assembled, as warehouse management and subsequent parcel delivery can be managed directly by the same logistics and distribution providers. Instead, restaurants can be considered a peculiar case, as they can either manage directly information flows and activities or rely on freight logistics and distribution providers for accomplishment of B2C parcel deliveries.
This design usually offers E-retailers opportunity to exploit inventory and facilities costs savings thanks to a centralisation process at warehouse level that favours achievement of economies of scale and product postponement due to customisation. Nevertheless, it can also present a few issues, such as a puzzling situation of inventory ownership structure that can risk causing sub-optimal choices with possible consequent aggregation losses and high efforts for coordination. Product category is a further possible limiting factor, as low-value items with predictable demand (e.g. items present in general grocery) result unsuitable for this type of trading. Actually, they have a high turnover rate feature that implies to have large availability of these products, which is a condition that does not fit with product postponement practice.
Since a single customer order can include items from different manufacturers, multiple shipments are necessary and it can happen that they occur at different times as well. This eventuality is a risk due to negative effects on both overall Supply Chain transport costs and customer service level. Then, facilities costs can be an extremely susceptible feature because of handling activities. Actually, they depend directly on either manufacturer's ability to manage small parcel deliveries or level of cooperation and coordination between manufacturer and freight logistics and distribution provider. A possible measure to either contain or exercise a positive effect on handling activities is to invest in ICT measures, as they can allow better coordination and integration of operations.

4.4.2 Manufacturer storage with direct shipping and in-transit merge

This distribution network design gives the opportunity to achieve a reduction of transport costs compared to the "Manufacturer storage with direct shipment" option. Actually, before parcels reach

end-consumers, they pass through an intermediate step in which the different products coming from several manufacturers get to an in-transit merge facility. Here, they undergo an aggregation process in order to form parcels that are going to be delivered later to end-consumers. Additional benefits of in-transit merge facility are inventory aggregation and product postponement.
This freight logistics and distribution network design results a suitable option for products of high value with poor demand predictability. Implementation of this in-transit facility usually requires consistent investments in ICT infrastructures in order to achieve coordination of in-bound and out-bound operations. Actually, scarce operational coordination levels in this design can lead to delays of parcel deliveries and insufficient order visibility. ICT costs can undergo an increase if the manufacturers' base is too large. Moreover, if on one hand this intermediate facility favours a reduction of transport costs thanks to the aggregation process, on the other investments in facilities and handling operations can be quite consistent.

4.4.3 Distributor storage with carrier delivery

In this distribution network design, the inventory is located at retailer level and freight logistics and freight logistics and distribution providers have the task to conduct and manage B2C parcel delivery operations. Such inventory management practice is quite common for commercialisation of products with a high demand or in other words with a high turnover rate.
Parcel deliveries are usually performed directly to end-consumers' addresses. Therefore, opportunity to lower transport costs and foster response time performance of the service can be achieved by bundling together multiple customers' parcels, maybe according to specific criteria.
In this design, facilities costs usually cover a consistent part of overall expenses, as the intermediate warehouse has to own sufficient dimensions and the operations that occur inside have to ensure a sufficient level of freight aggregation.
Tin general, this distribution network design does not present high ICT costs features, as the backward section of Supply Chain (between E-retailer and manufacturer) needs relative less attention. However, accurate investments on software for optimisation of demand forecast, shipment scheduling and routing path planning can favour improvements of the service.

4.4.4 Distributor storage with last-mile delivery

This freight logistics and distribution network design is suitable for large part of both perishable and non-perishable products. Despite the warehouse is located at retailer level, this design does not give the opportunity to conduct B2C parcel delivery operations across a wide customers area. Instead, it is quite common to adopt this freight logistics and distribution network design to perform B2C delivery operations in densely populated areas through the implementation of a two-tier system of warehouses (central DC and smaller warehouses). Aim of this strategy is to serve multiple districts within a relatively large operational area. Therefore, facilities costs are expected to be a significant investment that can compromise the possibility to reach sufficient level of freight aggregation with possible negative consequences on inventory costs. A common strategy to exploit transport costs containment implies to designate freight logistics and distribution providers the task of performing B2C last-mile parcel delivery operations. Actually, these professional figures usually own personnel of higher capabilities and skills that can use more sophisticated equipment in order to manage commercial operations optimally. If successfully implemented, this strategy give the opportunity to achieve costs amortisation. However, in order to benefit of this transport and facilities costs savings, considerable investments in ICT infrastructures are needed.

4.4.5 Manufacturer or distributor storage with customer pickup

In this design, end-consumers place orders through online sale platforms whilst products can be partially stored at either manufacturer or retailer level depending on their turnover rate. Compared with other distribution network designs, parcels are not going to be delivered directly to end-customers, but instead they are transported to specific facilities that can have different locations. In order to enable end-customers to collect parcels, freight logistics and service providers inform end-customers by means of notifications (e.g. email, text message) that contain details about location and expected time of their parcel deliveries. The locations where parcels are dropped-off are known as "pickup points" and there are different types with relative benefits and downturns. As example, besides the conduct of the normal business activity, certain stores (e.g. flower shops, tobacco shops) can perform pickup point function and they can even assume part of inventory costs by holding fast-turnover products. This type of pickup point can be also named "attended pickup point", as the personnel of the store is the collect the parcels directly from the delivery operator. Otherwise, an alternative option for pickup points is the implementation of a network of facilities (e.g. lockers) that do not need any presence of personnel in order to perform their task. They are commonly named "unattended pickup points". Independently from the type, pickup points can favour an additional containment of transport costs thanks to shorter distance that freight logistics and service providers have to travel in order reach a pickup point location compared to go to end-customer's address. Facilities costs can have different impact on freight distribution network depending on number and type of pickup points. Actually, it is common practice that independent business activities performing pickup point function receive a compensation based on either number of parcels or storage capacity dedicated to parcels. Instead, unattended pickup point usually require investments in terms of security measures, as they have to protect parcels from possible thefts. As previously mentioned, end-consumers have to travel to these locations to collect parcels and this requires to implement a systems that notifies them about the delivery. Therefore, a potential significant costs feature of this distribution network design is ICT infrastructures due to the need of ensuring a minimum sufficient level of order visibility for informing end-customers about either time or pickup location where parcel delivery has occurred. As attended pickup could hold part of inventory, it might be that investments in ICT infrastructures can be even larger due to the need to implement effective and efficient replenishment planning activity.

4.4.6 Retail storage with customer pickup

Mass retailers (especially big retail chains) that operate through both local physical stores and online shops often use this freight distribution network design. Here, end-customers can place orders in different modalities (e.g. by phone call, email or online shop) and collect the parcel at the physical stores later. Therefore, local stores assume a similar function to pickup points, but facilities costs can significantly rise because of the relatively limited size of stores that makes difficult to achieve a sufficient products aggregation level to sustain sales at both "Brick and Mortar" and online shopping levels. Other negative effects can be observed at inventory costs level, as its management becomes harder as well. Actually, items of different turnover rate are stored at different levels of the Supply Chain (e.g. local stores hold very fast and fast moving items and CDCs hold very slow and slow products). Therefore, the opportunity to shop online forces to allocate part of financial resources on ICT infrastructures measures, as it is necessary to ensure efficient and effective conduct of products replenishment planning and order visibility for end-consumers. Moreover, investments on ICT infrastructures are usually needed in order to achieve a

sufficient level of coordination and integration levels between CDCs and local stores in order to plan efficient replenishment planning and optimise inventories management as well.
Transportation costs are a marginal costs feature, as freight transportation occurs exclusively between CDCs and local retail stores by means of Large Heavy Vehicles (LHVs), such as trucks.

4.5 Supply Chain for perishable products distribution network designs

Perishability is the peculiar characteristic that distinguishes perishable from the non-perishable products. Although such significant diversity, it is interesting to notice that perishable products do not need specific logistics and distribution networks designs, but instead large part of the aforementioned designs are still valid. Therefore, the difference compared with non-perishable products does not concern the structure of the freight logistics and distribution network. Instead, sensitivity due to the perishable nature of the products is the cause of the implementation of certain measures at level of physical facilities and management of operations, such as loading, unloading, transport and storage (Punakivi et al., 2001; Bramel and Simchi-levi, 1996) that can result in a significant increase of Supply Chain costs features compared with non-perishable product management. For instance, perishable products need facilities and transport means equipped with refrigeration technologies or more sophisticated ICT measures than the ones usually implemented Supply Chain for non-perishable products. These higher operational requirements are the main reason for the higher average costs features of Supply Chains for perishable products. A missed application of such measures could compromise not only product quality from a hedonistic perspective with consequent customer's dissatisfaction, but it can also be a potential safety risk for human life (Bharti, 2014; Montanari, 2008).

Further difference between Supply Chain for perishable products and conventional Supply Chain concerns the understanding of the terms manufacturer. Actually, it does not have to be understood as firm, but instead it refers to either food restaurant chains or single shops offering ready-made meals delivery service. In case of large food retail chains, the usual starting point of B2C parcel delivery operations are large DCs (or local retail stores of sufficient size), as for large part of E-retailers usually do for sale of non-perishable mass-market products. Despite this similarity, reasons behind using DCs as starting location for B2C parcel delivery operations are different., as they concern inventory and facilities issues. Actually, not all the local shops of large food retail chains own sufficient level of inventory to sustain both sale channels (physical stores and E-grocery service) (Hsu et al., 2007; Boschma and Weltevreden, 2003). Then, as previously argued, facilities costs can have a significant impact on cold Supply Chains, as perishable products need equipment and personnel able to perform temperature maintenance and control and a careful product management based on expiration date until exploitation of B2C parcel deliveries. All these measures aim to prevent raise of extra costs caused by physical product losses or customer's dissatisfaction due to improper conduct of operations (Bharti, 2014).
Once either meal or grocery orders have been assembled, next step is to perform parcels transport to end-consumers. Distance is a factor that can affect the level of requirements to fulfil in order to manage properly and effectively perishable products. For instance, common practice is the implementation of refrigerated cargos when large batches of perishable products are moved from DCs to local retail stores. In these operations, it is common to use sensors (e.g. data logger) whose task is to monitor a set of different parameters (e.g. temperature, humidity, carbon di-oxide or pH level). In case of shorter distances, as it usually occurs in B2C deliveries of ready-made meals or grocery, such control measures requirements can have lower standards, which allows the adoption

of less sophisticated equipment (e.g. ice packs and poly-boxes) that aim to exploit same function (Montanari, 2008).

Finally, the last step is parcel reception and n case of delivery of perishable products, this last step of B2C delivery service can assume different modalities.
Probably, the most effective way to exploit temperature preservation is to implement attended parcel deliveries at end-customers' home. Actually, this modality offers the advantage to achieve higher control and maintenance of temperature, as end-consumers are present at the time of the delivery, which makes possible almost an immediate storage of parcel, as chain maintains its integrity.
Nevertheless, nowadays it is more common to observe B2C grocery deliveries (less in case of ready-made meals) at unattended pickup parcel reception facilities either at customer's home address or (less often) to other unattended locations. When these solutions are implemented, freight logistics and distribution providers have to adopt certain measures to maintain intact temperature for a time span sufficiently long to enable end-customers to reach the pickup location and find products still in good conditions. Common equipment to achieve such goal are containers for thermal insulation and additional ice packs for food products that need refrigerated temperature (Punakivi et al., 2001).

4.6 Reverse Supply Chain distribution network designs

As the various freight logistics and distribution network designs allow performing B2C parcel deliveries in different, design and management of product returns can assume various forms. The effect is to observe different level of product returnability (Chopra and Meindl, 2016).

Analysing the "Manufacturer storage with direct shipping" design, for E-retailers of mass-market management of returns results quite difficult, as products have to go back until manufacturers, which can be in different locations, which risks to lead to a multiplication of product return flows. Chopra and Meindl (2016) have proposed two options that can affect differently Supply Chain costs. The former is a direct shipment made by end-customers towards manufacturers, but this option is quite demanding in terms of transport and communication-coordination costs. The latter consists in the setup of a network of facilities (similar to pickup points), whose task is to handle only product returns. Of course, this second option of product returns management affects facilities costs feature.

Since a product entering reverse Supply Chain can be allocated to different final destinations, a selection process is needed in order to identify and put each product on the right reverse flow, as this process can affect significantly profitability levels (Enarsson, 2002). In order to standardise these returns selection procedure and have control on costs, specific actors can manage this process within certain facilities: they are named gatekeepers and return centres respectively. As it happens for Supply Chain forward flows, freight logistics and distribution providers own the needed technical skills to manage reverse product flows as well (Ravi and Shankar, 2005).
"Distributor storage with carrier delivery" is a freight distribution network design that offers the opportunity to perform a good returns management. Actually, the warehouse is located at the retailer level, where all handling activities for order assembling are performed. Therefore, the eventual additional tasks of managing product returns operations would not be a significant challenge for freight logistics and distribution providers. Furthermore, the event that end-customers

can return many products just through a single shipment can be an additional benefit, such as transport costs can be minimised.
"Distribution storage with last-mile delivery" is a design that makes possible to manage returns better than the previous options. The reason supporting the choice of this design is that the conventional delivery vehicles for B2C parcel delivery transport multiple parcels and consequently perform multiple deliveries. The opportunity is to integrate simultaneously parcel delivery and returns flows. Then, as it occurs in the "Distributor storage with carrier delivery" design, the central warehouse offers the possibility to perform quite effectively and efficiently product returns management with the same workforce that manages forward Supply Chain product flows.

Finally, "pickup points" design can offer a certain degree of flexibility for exploitation of product returns management depending if these locations can exploit or not storage function. The result is to observe probably different Supply Chain costs structure. Returns handling would result more manageable in case pickup points are of the attended typology (e.g. physical shops of the same brand of the product that end-customer want to return). Nevertheless, it has to be considered that these shops could not be optimally located for all consumers and they have closing hours (e.g. weekends). Instead, if on one side the use of unattended pickup locations (e.g. lockers) offer to return parcels 24h/7d, it requires an integration of additional management procedures in case end-consumers need to initiate product return procedure. Main interventions would concern ICT costs, as it has the setup of a system to inform about the need to collect a product return from a pickup site.

The decision-making process for the application of one of the aforementioned reverse Supply Chain designs will be for large part based on two pillars: product/market characteristics and socio-political environmental concerns. For these reasons, a few studies within the body of the literature have argued that reverse Supply Chain can assume forms either more or less environmental-safety driven, costs-efficient driven or market-responsive driven (Janse, 2008; Krikke et al., 2003).

5. Literature review about urban mobility and freight transport regulation

Urban mobility is a composite concept because it engages a plurality of stakeholders and each of them express unlike effects on urban environment due to their different roles and respective powers (Witkowski and Kiba-Janiak, 2014; Russo and Comi, 2010).

The body of the literature of the last decades is plenty of studies about the effects that economic and technological development have had on society. For instance, it has been proved how Internet has modified customers' purchasing behaviour, especially in people living in urban areas (Pappas et al., 2016; Hernández et al., 2010; Li et al., 2007; Cheung et al., 2005; Lohse et al., 2000). This new modality of product purchasing has affected urban environment, but there are heterogeneous opinions about its effects. Actually, a few studies expect environmental benefits thanks to lower need to do personal shopping trips (Hopkins and McCarthy, 2016). Instead, others authors (McKinnon et al., 2009; Weltevreden and Rotem-Mindali, 2009; Dablanc, 2007) support the opposite idea that the increasing demand for B2C parcel delivery service, combined with parcel disintegration phenomenon and scarcity of urban land (caused by intense urbanisation process), would overcome any possible reduction of personal shopping trips. By consequence, risk is to observe a worsening of urban areas conditions under several aspects, such as a potential significant growth of traffic flows and consequent traffic congestions, accidents and even possible fatalities that makes harder for freight logistics and distribution providers to conduct operations.

Other than affecting urban mobility, road freight transport can affect urban areas from an environmental perspective as well. Actually, as supported by part of the literature (ALICE and ERTRAC, 2012; Russo and Comi, 2010), road freight transport, which is still largely based on use of fossil fuels, is a major responsible for the increase of Green House Gas (GHG) emissions in urban area, accounting for forty per cent of overall CO_2 emissions. Moreover, road freight transport has been related to another negative phenomenon of modern urban areas: the excessive level of noise exposure. This last issue has usually received poor attention by urban stakeholders (especially freight logistics and distribution professionals and regulative authorities), as its effects remain on a local scale compared with air pollution (e.g. GHG emissions affect both local areas and are responsible for global climate change). Nevertheless, certain studies have proved that significant level of noise exposure can express severe effects on quality of urban life and even on human health (Papoutsis and Nathanail, 2016; Goines and Hagler, 2007).
All the aforementioned issues concerning urban road freight transport can be translated in external costs for society. An example of this quantification process can be found in ALICE and ERTRAC (2014) and Russo and Comi (2012).
Furthermore, regulative authorities are other subjects that can affect urban areas from both mobility and environmental perspectives. This last category includes two different actors: lower-level regulators (or urban authorities) and higher-level regulators (e.g. national governments or international authorities). Decisions taken by these two regulative actors affect differently freight transport at different levels. Actually, local authorities' measures have a strong influence on management of urban traffic flows and they can vary among cities (Witkowski and Kiba-Janiak, 2014). Instead, higher-level regulative authorities' decisions have a wider impact, as they are responsible to set rules and norms that logistics and distribution industry has to respect and fulfil in order to exploit the commercial operations.

The underlying sub-sections will offer an overview of the possible measures that aim to improve urban mobility in European cities based on the information gathered during the literature review activity. The discussion will start from measures adopted by freight logistics and distribution providers, then urban authorities' solutions and finally higher-level regulative authorities' role.

5.1 Freight logistics and distribution service providers' mobility measures

As mentioned earlier in this chapter, freight logistics and distribution service providers have an active role in defining the general level of urban mobility. However, the usual decision-making process aims to maximise efficiency and effectiveness of operations whilst fulfilling legal requirements. Freight logistics and distribution providers' options are heterogeneous. A common measure is the adoption of Best Managerial Practices (BMPs), as they are usually relatively cheap and easy to integrate in ordinary operations. Beyond possible improvements in conduct of operations, BMPs can also provide secondary benefits. For instance, the basic BMPs option of specialised trainings to enhance parcel delivery operators' driving behaviour, despite its limited overall impact, can favour a reduction of fuel consumption and pollution emissions (e.g. GHG, PM) as well (Piecyk and McKinnon, 2010). However, freight logistics and service providers can implement sophisticated measures to enhance operational performance while improving urban mobility as well. In the last years, the main trend in freight logistics and distribution industry has been to invest in ICT infrastructures, such as track and trace systems (for a higher customer's parcel visibility) to intelligent routing systems (for optimisation of time and energy consumption of operations). Adoption of BMPs can occur at reverse Supply Chain level as well. Freight logistics and distribution providers can improve environmental and economic performances by optimising product returns management and this goal can be indirectly achieved through careful selection of distribution network design and/or ICT infrastructures that minimise the number of re-deliveries (Hopkins and McCarthy, 2016; Van Duin et al., 2016; Weltevreden, 2008; McKinnon and Tallam, 2003). Finally, another freight logistics and distribution providers' initiative concerns the use of vehicles equipped with more sustainable propulsion system technologies, as reduction of energy intensity can offer the opportunity to both conduct more environmental friendly operations and favour a reduction of operational costs (Hopkins and McCarthy, 2016).

5.2 Urban authorities' mobility policy measures

Although freight logistics and distribution providers' private initiatives (e.g. BMPs) can affect positively mobility of urban areas, they remain measures with palliative effect due to their strong orientation for optimisation of commercial activity (Hopkins and McCarthy, 2016). A different class of urban stakeholders can take decisions able to affect either positively or negatively urban mobility on a larger scale. They are urban authorities (alias lower-level regulative authorities).
According Witkowski and Kiba-Janiak (2014), literature is plenty of examples concerning urban authorities' measures that make them an influential stakeholder of urban areas. Actually, urban authorities' choices, which are the output of a decision-making process, affect all traffic flows (commercial, private and public) within the urban space. However, they can also target a specific class of traffic flows. Actually, urban authorities adopt commonly a set of mobility policies based on heterogeneous criteria to regulate commercial traffic flows within urban space. For instance, a few well-known regulative measures are limited access areas based on vehicle' category and size, time windows or even propulsion system technologies (ALICE and ERTRAC, 2014). General goal of urban authorities' regulative measures is not the only optimisation of overall traffic flows, but also a reduction of levels of air pollution and noise exposure in order to create a more liveable urban environment for citizenship. Actually, during last decades, these last two phenomena have become serious issues of modern urban areas, as part of the literature has considered them as major factors with worsening effect on citizens' health status (ALICE and ERTRAC, 2014; Milford et al., 2012).

5.3 Higher-level regulative authorities' measures for freight transport

Although freight logistics and distribution providers and urban authorities have a close engagement in defining the dynamics of urban traffic flows, other subjects are also able to affect urban mobility. These further stakeholders are international organisations (e.g. European Union) and national governments, which represent the regulative authorities owning the highest degree of decision-making power.

Compared with the other two parties, higher-level regulative authorities have usually an indirect impact on urban mobility, as their decisions concern the definition of norms and rules that exceed urban borders. Actually, their influence extends across the national territory or even across nations (Ducret, 2013). According to the words of the official webpage of the European Commission (in the sub-section "Mobility and Transport"), general goal of these regulations is:

"…to promote mobility that is efficient, safe, secure and environmental friendly."

(Source: europa.eu)

For instance, during last years, European higher-level regulative authorities have contributed to development and support financially mobility projects across several European cities whose aim has been to enhance both urban mobility and urban quality of life (van Rooijen and Quak, 2014). However, higher-level regulative authorities usually express their influence through definition of norms and rules that the various subjects engaged in traffic flows have to respect and fulfil in order to own the legal rights to move along mobility infrastructures. As example, concerning road transport regulation, it is possible to find measures aiming to promote the achievement of a more sustainable mobility (e.g. Directive 2009/03/EC on the promotion of clean and energy-efficient road transport vehicles). Instead, Reg. (EC) N° 611/2009 and Reg. (EC) N° 78/2009 are norms concerning general safety of motor vehicles and pedestrian protection respectively that apply to heterogeneous vehicle classes. Higher-level regulative authorities' measures can also target specific vehicle categories by means of specific regulations, such as commercial vehicles for freight transport. For instance, Reg. (EC) N° 561/2006 concerns the maximum driving time and minimum breaks and rest periods requirements on different time base for drivers of vehicles over 3.5 tonnes or Reg. (EC) N° 347/2012 and Reg. (EC) N° 351/2012 (concerning the mandatory integration of certain safety systems on certain truck models). Therefore, it can be reasonable to expect that higher-level regulative authorities would have a role in setting measures that will norm the application of autonomous UAVs as commercial vehicles for B2C parcel deliveries operation in urban context.

6. Theoretical framework

This chapter contains the theoretical framework of this research project. It depicts the network of the relationships among the research concepts based on the findings of the literature review activity. The concepts and their relative components can have either direct or indirect influence in defining the possible overall performance level and the regulative framework of UAVs exploiting B2C parcel deliveries in urban context. In the next page, Figure 4 represents the graphical representation of the theoretical framework for this master thesis project.

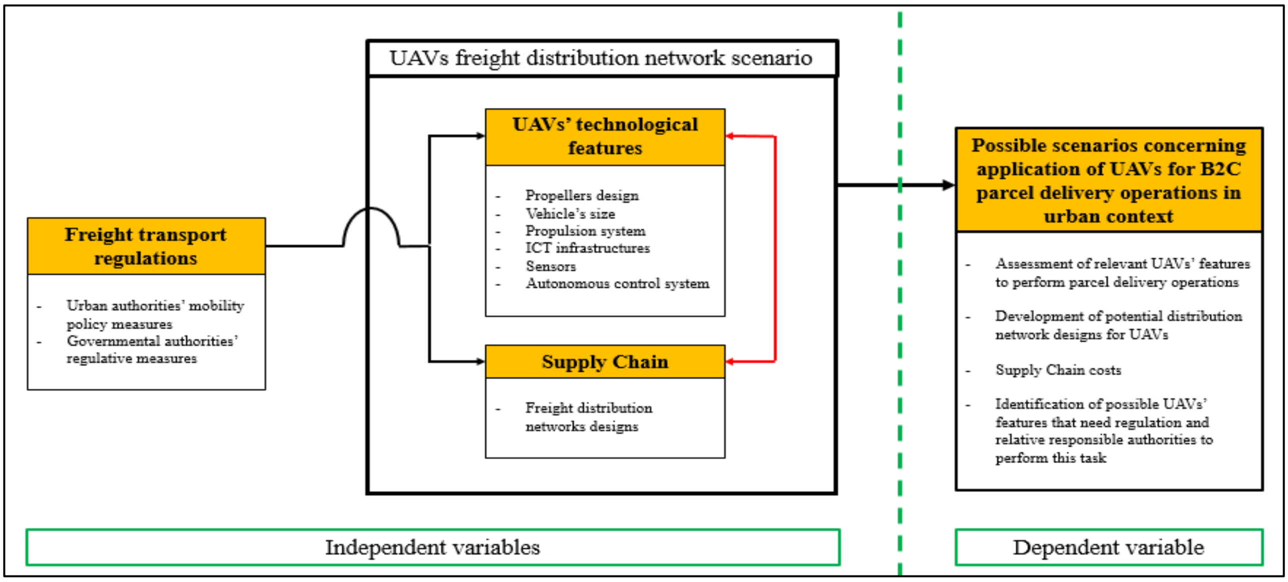

Figure 4: graphical representation of the theoretical framework of the master thesis project.

Before providing details about the interactions between the elements forming the theoretical framework, a notification is needed. "UAVs B2C parcel delivery network scenario" is a peculiar feature of the framework, as it is formed by two concepts (Supply Chain management and UAVs' technological features) that exercise a reciprocal influence and together affect the dependent variable (corresponding to the objective) of this research project.
The next lines will offer more details about the relationships that characterise this theoretical framework.

Concerning the "Supply Chain" concept, the student has decided to investigate on a selection of the freight distribution network designs presented by Chopra and Meindl (2016). The designs, which are included in the research project, are:

- Manufacturer storage with direct shipping
- Distributor storage with carrier delivery
- Distribution storage with last-mile delivery
- Manufacturer or distributor storage with customer pickup

There are several reasons that support the student's decision to consider these four freight distribution network designs in this research project. First, parcel reception modality is an aspect that needs attention. Actually, it can be either attended or unattended and the former option can assume two other forms depending if delivery operator drop parcels directly at the end-customer's address or at an attended pickup point. Instead, the unattended modality consists in delivering parcels to specific facilities that do not need human presence in order to exploit parcel reception function. Additional reasons to include the aforementioned designs are the different architecture (e.g. either presence or absence of in-transit merge facility that affects inventory structure), product returns management and eventual differences in managing either perishable or non-perishable products.
Student's decision to exclude "Manufacturer storage with direct shipping and in-transit merge" and "Retail storage with customer pickup" designs from the investigation activity is based on two main reasons. The first design has many similarities with "Distributor storage with carrier delivery" option. Instead, the second one represents the traditional "Brick and Mortar" system, in which end-

consumers usually perform order fulfilment and parcel collection first hand at the physical store. Therefore, this last case does not need any parcel delivery service.

The research concepts “Supply Chain management” and “UAVs’ technological features” express a reciprocal influence on each other, as part of the literature has suggested (Hosseini and Shirani, 2011; Cottrell, 2008). Actually, decisions concerning parcel reception modality and logistics and distribution facilities affect the operational range of a distribution network, which in turns defines requirements in terms of vehicles’ size and propulsion system in order to sustain operations for a certain time span. Moreover, depending on the product categories (perishable or non-perishable products), requirements in technological features can be different, as it occurs at ICT infrastructures level. However, it is true that choices concerning technological features influence the Supply Chain management concept as well. For instance, decisions concerning implementation of certain vehicles’ size and/or ICT infrastructures can limit the possible choices in terms freight logistics and distribution networks designs, as the formers may require specific logistics facilities and Supply Chain managerial practices.

Among the elements that compose the “UAVs’ technological features” concept, a few of them are specifically related to these unmanned aircrafts (e.g. autonomous control systems, propellers design). Instead, other are more generic but significant features related to the freight logistics and distribution industry, such as vehicle’s size and type of propulsion systems. According to student’s opinion, all of them can define the objective of this research project with different degree of influence. Especially, vehicle’s size and propulsion system are features that affect directly vehicle’s transport capacity of commercial vehicles and thus express a relatively significant effect on operational costs (Hosseini and Shirani, 2011; Keebler and Plank, 2009). As UAV are an unconventional vehicle type compared to traditional road commercial vehicles and considering only B2C parcel deliveries within the larger world of freight logistics and transport operations, the student has decided that assessment of UAVs’ transport capacity based on ton-kilometres or volume would result meaningless. Therefore, this research project will adopt the average payload weight as unit of measure to assess UAVs’ transport capacity.

From the aforementioned considerations, it is clear that the concepts forming the composite feature “UAVs freight distribution network scenario” are fundamental and meaningful elements of the theoretical framework. Together they define partially the research objective and especially they express their influence on operational aspects, such as structure of distribution network design, specific practices and equipment to manage certain product categories and the Supply Chain costs features as well. Table A1, which has been positioned in the appendix, provides an brief and clear explanation of these cause-effect interactions.

However, as it occurs for commercial road vehicles for freight transport, it is reasonable to expect that autonomous UAVs will need to respect and fulfil certain norms and standards in order to be legally authorised for performing B2C parcel delivery operations in urban areas.
The author is interested in assessing which technological features and safety requirements autonomous UAVs have to respect and fulfil in order to prove to be able to conduct B2C parcel deliveries in urban context with a sufficient level of reliability. Technological features that could be regulated are various and they can be similar to the ones of road freight transport (e.g. propulsion systems, vehicle’s size), but also a specifically related to UAVs. For instance, the possibility to perform B2C parcel delivery operations autonomously is a completely new event that needs

regulative authorities' attention. Therefore, this research project will investigate on possible measures concerning the regulation of the most characteristics of autonomous UAVs: Autonomous Control Systems and Detect-Sense-Avoid (DSA) systems. Actually, the current level of autonomy of UAVs' control systems is unlikely defined by several national and international organisations (e.g. US Air Force, National, United States Department OF Defence (USDOD), Institution of Standard and Technology (NIST) and North Atlantic Treaty Organisation (NATO)). Regulation of Detection-Sense-Avoid (DSA) system is important as well, as the large variety of different pieces of equipment forming this device can provide offer a range of different degrees of performance, which consequently define unlikely level of reliability (Sevcik and Oh, 2008).

In the event that multiple fleets of UAVs will operate simultaneously in the same urban air space, use of certified autonomous control systems and DSA systems could be necessary, but not sufficient measures to guarantee reliability and safety of operations. A common ICT network infrastructure for data sharing-coordination-integration might be required for autonomous UAVs performing B2C parcel delivery operations. Actually, ICT infrastructures are not only logistics and distribution providers' measures to optimise conduct of operations, but regulative authorities could perform control and monitoring activities through them in order to reduce risk of accidents by detection violations and applying relative sanctions. Manned aviation uses the same approach, since a Civil Aviation Agencies (CAAs) control, monitor and manage air traffic flows in collaboration with airlines companies. Therefore, this research project will try to assess the eventual modalities and subjects appointed to perform tracking-control-monitoring of autonomous UAVs operating in urban air space.
Finally, although the idea concerning conduct of B2C parcel deliveries through UAVs is based on the use of autonomous vehicles, the professional figures of parcel delivery and UAV operators are not expected to disappear. It might be that autonomous unmanned aircrafts would require a new professional figure whose tasks and duties are different compared to the common parcel delivery operator's ones. In order to have legal rights to operate with autonomous UAVs, regulative authorities could ask to fulfil certain compulsory requirements, such as specialisation trainings, as proof that the operator has both acquired the knowledge and development the skills to perform such job (Protti and Barzan, 2007).
However, as argued in relative section of the literature review, these norms and standards can be defined by either urban or higher-level regulative authorities, which express their respective influence at different levels due to due to their different degree of authority. Therefore, the author will try to assess which aspects of urban B2C parcel delivery operations by means of autonomous UAVs the two types regulative authorities will be responsible to norm respectively.

7. Methodology

The chapter entitled "Methodology" includes information concerning the research strategy, research methods and sampling technique that the student has adopted in order to conduct this master thesis project. Moreover, there are explanations about how the operationalisation process of the research instrument has been administered. Finally, there is also a brief discussion about the validity and reliability of the overall research project.

7.1 Research strategy

Aim of the thesis project has been to investigate the potential scenarios concerning UAVs' application in B2C parcel delivery operations in urban context. According to the guidelines suggested by Kumar (2014), this research project can be classified as case study with a "mixed method" approach. Actually, it presents a strong explorative nature, as it attempts to obtain a holistic understanding of the phenomenon under analysis by means of an in-depth information gathering process that involve different information sources.

7.2 Research methods

Base of the information gathering process has been both primary and secondary data sources. The former have been obtained by the conduct of a set of personal in-depth interviews and attending two conferences as well. Instead, a desk research activity has supplied secondary data. The following sub-sections will offer details about these data collection methods.

7.2.1 Desk research

Purpose of the desk research has been to provide significant and comprehensive knowledge about the elements representing the independent variables of theoretical framework (UAVs' technological features, Supply Chain and Freight transport regulations). These secondary data are pieces of information that the student has collected through consultation of secondary sources and these documents were in both hard and digital formats. A different set of research engines (e.g. Google Scholar, Scopus, Direct Science) has provided the access to this academic literature.

7.2.2 Personal in-depth interviews and conferences

Source of primary data for this master thesis project has been personal in-depth interviews of a group of heterogeneous stakeholders related to the topics forming the backbone of the theoretical framework. The student has chosen in-depth interviews as method to gather primary data because it makes possible to conduct investigation activity in a flexible fashion (Kumar, 2014). Due to the explorative nature of this project, the student has designed the respondents' interviews in a semi-structured format. Actually, the student has not developed a strict list of questions, but instead he has used the research variables as starting point for the discussion in order to have a better management of the interactions during the conduct of interviews. Depending on the respondent's area of expertise, the investigation has focused more on the relative topic in order to collect as much information and insights as possible. However, despite the student has tried to collect comments and expectations concerning other research variables in which a respondent does not own expertise in order to cover all the area of interest and have an overall picture. The interviews have followed a similar path in their development: first questions have been quite broad and then, if the respondent has proved to own a deep knowledge about the specific topic, the student has asked more detailed questions. The majority of the in-depth interviews has been in face-to-face format. Otherwise, in case of limitations caused by considerable geographical distance, the student has performed respondents' interviews through Skype calls.

To establish the first contact with a potential respondent, the master student has decided to send emails. Aim of the emails was:

- to introduce the student and his occupation
- to explain the main objective of the study
- to explain why respondent's collaboration was needed for this project
- to ensure that information gathered during interviews would have been managed properly and confidentially

If the contacted people have accepted to become official respondents for the research project, the next step has been the define time, day and general setting of the interviews.

Besides, the student has relied on additional sources of information for this master thesis project. Indeed, the master student has attended two different conferences. The first one was organised by the European Logistics Platform (ELP) organisation in November 2016 in Brussels (B) and it dealt with European logistics and mobility. Instead, the second conference was hosted in Bristol (UK) in May 2017 and the main topic concerned the commercial applications for Unmanned Aerial Vehicles (UAVs).

7.3 Sampling procedures

As the subject of this thesis project (possible scenarios from operational and regulative point of views of the application of UAVs for B2C parcel deliveries in urban context) needs an analytical process that involve multiple perspectives, the master student has given attention to the respondents' selection. Actually, he has selected and contacted people with specific expertise in order to gain in-depth information about the concepts forming the theoretical framework. A priori computation of the respondents sample size was not possible due to the strong explorative nature of the project. The master student has attempted to reach the data saturation point, which Kumar (2014) defines as point at which an extra interview will not offer any additional significant information.

Table 5 summarises the information concerning the topics that are going to be analysed, the relative respondents' area of expertise and professional role. The master student has decided to consider private, public and academic organisations, since their respective roles could offer different insights on the same topic.

Research topic	Expertise area	Expert's role
UAVs' technological features	- Aeronautical sciences	- UAVs manufacturer - Professional UAVs user
Supply Chain	- Supply Chain management	- Supply Chain manager - Cold Supply Chain manager - Reverse Supply Chain manager - E-sales manager - Logistics facilities manager
Freight transport regulations	- Road/Air freight transport regulation - Urban mobility policies	- Mobility and Transport regulator - Freight logistics and distribution professional - Urban planner/designer - Urban environmental manager

Table 3: description of expertise area and relative respondent's role according to the specific research topic.

7.4 Validity and reliability

Validity is the concept that refers to the intrinsic ability of a research instrument to measure adequately the phenomenon for what it was designed for. Instead, reliability indicates how much the research instrument is consistent and solid in providing similar results when the researcher perform repeated measurements under similar research settings.
According to Kumar (2014), validity can be discerned in two different categories. They are internal and external validity and they measure the credibility and the extent of generalisation of the research outcomes respectively. Both desk research and respondents' interviews guarantee internal validity to this master thesis project. Instead, external validity is partially fulfilled, as the student cannot include all the possible perspectives from which the research problem could be analysed (more details can be found in the chapter "Limitations and Suggestions for further research").
Finally, concerning the concept of reliability, the flexible design typical of studies with qualitative and explorative approach can affect research outcomes. Sources of possible influence for this research project can be respondent's opinions (due to their intrinsic human nature) and the social context.

8. Results

This chapter will present the outcomes that have been obtained from the respondents' in-depth interviews and information gathered by attending the conferences about European logistics and mobility and commercial applications of UAVs.
The master student has been able to interview eleven respondents that cover most of the needed areas of expertise. The following table (Table 6) will list all the respondents, type of expert and the relative areas of expertise.

Respondent #N°	Type	Area of expertise
#1	Academic	Urban mobility policies
#2	Academic	Supply Chain management
#3	Professional	Supply Chain management (freight logistics and distribution)
#4	Professional	UAVs and flight regulations
#5	Professional	Supply Chain management (freight logistics and distribution)
#6*	Professional	UAVs and flight regulations
#7	Professional	Supply Chain management (food retailing)
#8	Professional	UAVs
#9	Professional	UAVs and flight regulations
#10	Professional	UAVs and flight regulations
#11	Professional	UAVs
* Olivier Fontaine: accountable manager of SAPRITALIA and EASA expert group member		

Table 4: total number of respondents that have been interviewed with relative type and area of expertise.

From a simple observation of Table 6, it is possible to notice that the majority of the respondents come from the professional world and only two work for academic organisations. None of the contacted people working for either urban authorities or higher-level regulative authorities has been able to join the research project. Despite the unbalanced situation, the student has covered more or less all the areas of interest. Therefore, it is possible to assert that the results can be considered of a sufficient level of validity and reliability.

8.1 Results concerning UAVs' technological features

Results of respondents' interviews have proved that UAVs' technological features own a significant power, as they can determine the eventual application of these unmanned aircrafts for urban B2C parcel delivery operations. In the appendix of this document, the student has included two tables (Table A1, Table A2) that present in a brief fashion the outcomes of respondents' interviews concerning UAV's technological features. The reason to create two tables is an attempt to maintain order and clarity in the explanation.

First element to notice is that the vast majority of information concerning UAVs' technical features comes from respondents that either have had a professional experience in the aviation industry or are currently working with UAVs. Instead, due to lack of specific knowledge, both academics and the freight logistics and distribution professionals have provided basic ideas about technical characteristics that UAVs should own in order to perform B2C parcel delivery operations.

In general, among the respondents that have been able provide information, rotors and convertible UAVs have emerged as propellers design options that can allow conduct of B2C parcel deliveries in urban areas, but support for these designs is motivated by the different advantages and disadvantages that they can offer in this commercial context. Instead, respondents have excluded fixed wing design as eligible option to conduct parcel deliveries in urban areas, as they need large spaces for conduct of take-off and landing operations due to absence of Vertical Take-Off and Landing (VTOL) ability. Moreover, fixed wing UAVs have usually a bulkier structure, as wings have to be of a minimum size in order to generate a sufficient lift to sustain efficiently the aircraft during flight. According to respondents #4, #6, #8, #11, fixed wing design could be better exploited in a different commercial context, such as air cargo activity. Actually, the higher flight efficiency thanks to the high airworthiness level makes possible to cover longer distances in the same time span compared to rotors and they can do it even at lower energy consumption level, with consequent possible benefits in terms of transport costs. Concerning specifically the context of B2C parcel deliveries in urban areas, respondents 4#, #8, #10, #11 support the idea of rotors because this UAV design presents a series of technological characteristics that fit extremely well with modern urban environments. First, respondents have mentioned VTOL ability and the opportunity to maintain a compact design. Besides, rotors offer higher performance in terms of flight manoeuvrability, which increases flight stability and precision. However, respondents #4, #6#, #10 have mentioned the disadvantage of scarce airworthiness value, which can affect negatively energy consumption level. This eventuality is quite critical in a context like B2C parcel deliveries, as transport costs are part of the elements forming performance level of the service.
A few respondents (#4, #6, #8, #9) have suggested to apply convertible UAVs, as this propellers design combines both operational efficiency and VTOL ability of the other designs. Nevertheless, respondents #10, #11 (and in part respondent #4) believe that composite UAVs' general higher degree of complexity, which is caused by all moveable components, could compromise vehicle's robustness and it could require more investments for maintenance.

As it could be reasonable to expect, respondents have confirmed that transport capacity has a significant value in defining possible UAVs application for conduct of B2C parcel deliveries. Actually, academic respondent #1 and professional respondents #3, #5 have argued that this feature is a significant factor for commercial vehicles performing freight transport activity.
Concerning size/weight of UAVs, none has provided information about it. Instead, large part of respondents has related the eventual UAVs' transport capacity issues to two factors of different nature. Respondents #1, #2, #4, #9 have argued that regulative authorities could limit transport capacity based on principle to guarantee public safety. The other element concerns the current efficiency gaps of batteries (respondents #4, #6, #8, #9, #10, #11). They all agree on implementing electric propulsion system, but according to respondents #4, #6, #8, #10, #11 (and indirectly suggested by respondents #3, #5 with expertise in freight logistics and distribution), problem with batteries is not much related to power generation, but on the operational efficiency. Actually, current batteries do not offer sufficient level of reliability in various aspects. For instance, very

critical areas are batteries' sensitivity in terms endurance performance at weight variations (#4, #8, #9, #10, #11), unreliable recharging process and too short life cycle (#10). For these reasons, general respondents' expectations (with the only exception of respondents #6, #11) are that UAVs will not handle the same weight/number of parcels of conventional vans for parcel deliveries. It would be more realistic for them to observe the integration of these unmanned aircrafts with traditional freight distribution systems in order to optimise conduct of operations. Instead, respondents #6, #11 do not exclude the possibility that UAVs will transport heavy payload in future, but it would probably concern the application of fixed wing UAVs in air cargo context.

Both academic and professional respondents have asserted that in the event that UAVs perform B2C parcel deliveries in urban context, they will have to operate autonomously. Actually, they have identified application of autonomous UAVs as key factor to achieve operational costs benefits, as autonomous vehicles could considerably reduce need of human workforce, which is a significant costs voice in freight logistics and distribution industry (respondents #1, #3, #5, #7). A few (respondents #3, #5) have also suggested that autonomous control systems could lower accidents rate, as automation has been considered a phenomenon that can offer more standardised and reliable operations compared to human operators. Moreover, the higher autonomous control system's reliability and performance in conduct of operations has been suggested to offer costs savings, as it would be possible to extend time span of operations during night hours.

The majority of the respondents has unanimously asserted that sensors are important technological features for UAVs. Actually, sensors are fundamental components of DSA system. Sensors have the task to gather and transfer the necessary information to the autonomous control system to optimise the decision-making process based on external circumstances faced by the UAV. However, from the respondents' interviews, it has not been possible to identify a set of specific sensors that are going to form an official DSA system, as variety of sensors available on the market and the range of performance are quite wide. However, a few respondents (#4, #8, #9, #10) have suggested that cameras integrated with either sonars, lasers or optical sensing technology could be an option. Interesting finding of interviews is that large part of the respondents agrees that choices of sensors, which are fundamental components of DSA system, will not be only a UAVs manufacturers' decision. Actually, respondent #10 (UAVs manufacturer) has confirmed that his company is not investing much on this aspect due to the ambiguous regulative situation. Instead, the general idea is that regulative authorities will probably define standards and/or certifications for these devices in order to ensure that they offer a sufficient minimum level of safety.

Finally, according to respondents #4, #6, #8, #9, #10, #11, the application of autonomous UAVs in urban areas will require consistent investments in ICT infrastructures, as these have been considered an essential technological feature to achieve reliable and effective conduct and control of operations within complex environments, such as modern urban areas. In case of remotely controlled UAVs, ICT infrastructures have to enable and maintain a communication channel between UAV and Ground Control Station (GCS) as main goal. Otherwise, in presence of various fleets of autonomous UAVs the situations will assume a different perspective, as communications will have probably to occur among multiple UAVs, GCSs and maybe an independent regulative authority. With exclusion of just few respondents (#1, #2, #7), all the others have cited Global Positioning (GPS) technology as basic ICT infrastructure for UAVs. However, the only use of GPS is not sufficient and respondents believe that an additional ICT infrastructure measure needs to be integrated. Actually, despite GPS allows UAVs to perform basic autonomous flight, this is considered an insufficient performance level for conduct of operations in urban areas due to presence of multiple externalities (e.g. physical obstacles, scarcity of space, and high density of people). Furthermore, all respondents with expertise in UAVs or flight regulations (#4, #6, #8, #9, #10, #11) have mentioned how precision of GPS technology is sensitive to natural events (e.g. solar storms, weather conditions).

8.2 Results concerning freight distribution network designs

This sub-section contains all the respondents' opinions about the freight logistics and distribution network designs (selected after the literature review activity) on which investigative process has focused in order to define possible suitable designs for the application of autonomous UAVs in B2C parcel delivery business. The tables (Tables A3, A4, A5, A6) containing an overview of all the finings concerning each freight logistics and distribution network design have been positioned in the appendix at the end of this document.

8.2.1 Results of "Manufacturer storage with direct shipping" design

From Table A3, it is possible to notice that only a few respondents (independently from the type) have expressed an opinion about "Manufacturer storage with direct shipping" design. According to their opinions, this design is unsuitable (respondents #1, #4) or with limited applicability (respondents #2, #3) for generic E-retailers that would offer B2C parcel delivery service by means of UAVs. Actually, respondents #2 and #4 have argued that shopping through online channels (especially E-market place) can involve several manufacturers that are usually located in different and distant places from end-customers. To deliver a parcel of limited weight, which is a common event in online shopping, would result extremely cost inefficient. Furthermore, the same respondents have mentioned that manufacturers do not usually own the necessary knowledge and skills to manage batches of small sizes. Actually, traditional batch size at production level are large and if they want to either manage and perform directly B2C parcel deliveries or collaborate with a logistics and distribution providers, manufacturers would have to do significant investments in ICT infrastructures, labour and equipment.
The situation is completely different if the term "Manufacturer" is understood as shops and/or restaurants chains offering ready-made meal delivery service. Actually, application of these unmanned aerial vehicles to deliver ready-made meals to end-customers could result a faster service than traditional road deliveries for two main reasons: direct-line flight and opportunity to avoid urban road traffic. Moreover, a faster delivery could offer the advantage to implement basic temperature control measures (e.g. poly-boxes, ice packs, insulating cardboards) even at longer distances than the conventional ones covered by current ready-made meals road carriers, with possible exploitation of costs containment and customers' base expansion.

8.2.2 Results of "Distributor storage with carrier delivery" and "Distributor storage with last-mile delivery" designs

Other distribution network designs have found a larger consideration among respondents, as they think that these designs own a more suitable structure for an eventual application of UAVs. However, respondents have heterogeneous opinions in support of the implementation of one of the two underlying freight logistics and distribution designs.

First thing to do is provide an explanation of why these two freight logistics and distribution network designs have been presented together in this sub-section. From the observation of Table A4 and Table A5, first thing to notice is that respondents have considered "carrier delivery" and "last-mile delivery" as very similar freight distribution network designs. Actually, differences among them concern a single characteristic: UAVs' operational endurance. If propulsion systems (granted that they are reliable) should achieve a sufficient efficiency level, UAVs could perform B2C parcel delivery operations starting directly from central warehouses or cross-doc areas, which are generally located quite far from end-consumers (respondents #2, #3, #4, #5, #8). Otherwise, in the opposite scenario where operational endurance remains limited, respondents have proposed two different visions of a possible distribution network design. Respondents #1, #2, #5, #8 have suggested a design based on the "hub-and-spoke" logistics principle. Here, Central Distribution Centres (CDCs) will consolidate freight in order to perform then assembling and delivery of multiple batches of parcels to Urban Distribution Centres (UDCs), which are second-level warehouses closer to urban area. From UDCs, UAVs will start B2C parcel delivery operations and they will operate within an assigned area. However, the same respondents (#1, #2, #5, #8) have expressed concern about the possible costs in terms of physical facilities and ICT infrastructures for this distribution network, especially if implemented by a single business organisation by means of personal financial resources. Furthermore, according to respondent #2, such individualistic approach risks to cause a phenomenon of duplication of facilities that can worsen further the already compromised condition of urban land use. The alternative option in case UAVs will have a limited operational endurance concerns the integration of UAVs with traditional vans for parcel delivery. Respondents #8, #11 have mentioned that big players of freight logistics and distribution industry have already started to address their attention on the possibility to implement such design. The fundamental idea is that vans and human operator will assume a double function. Actually, vans will remain a vehicle for parcel delivery and simultaneously it will assume the role of mobile Ground Control Stations (GCSs). Instead, the human operator will perform part of B2C parcel deliveries and he will have to initiate-monitor-control simultaneously one or more autonomous UAVs performing parcel deliveries. According to respondent #11, this new concept can offer certain benefits, such as flexible conduct of operations and it possible limited investments. However, the professional figure of delivery operator will change. From a mere operative function, the delivery operator would become a managerial figure, as he will have the additional task to plan and manage parcel deliveries for both himself and autonomous UAVs.

8.2.3 Results of "Manufacturer or distributor storage with customer pickup" design

Concerning a possible integration of UAVs with "customer pickup" distribution network design, respondents' opinions are quite heterogeneous. For instance, respondents #3, #5 (owning expertise in freight logistics and distribution) have argued that pickup points are considered the most favourable solution for freight logistics and distribution industry. Actually, these parcel reception facilities transfer part of the "last-mile" distance to end-consumers, as they have to go to specific locations in order to collect parcels. This event would reduce transport costs, as logistics and distribution providers travel for shorter distances. Moreover, it is possible to exploit better path panning, as pickup points are in fixed locations. Respondent #3 thinks that autonomous UAVs combined with automatized pickup points could give even the opportunity to perform night deliveries (not applicable to all product categories). However, implementation of pickup points design will probably be demanding in terms of investments, especially for a single company and respondents #1, #3, #4, #5, #8 have provided a few reasons. For instance, they have mentioned the need to implement this design at minimum scale in order to achieve operational efficiency, but this event will require investments in facilities and ICT infrastructures that can be extremely demanding for a single company. ICT infrastructures will be a key feature, as they will have to guarantee sufficient order visibility to enable end-customers to receive information about expected time and pickup point location of parcel delivery, plus technological solutions that can give access to the parcel (e.g. QR code reader). Actually, respondents #3, #5 (with expertise in freight logistics and distribution) have argued that business organisations, which aim to profit maximization, usually have a careful decision-making process concerning investments, as these last ones should foster business performances. Therefore, willingness to invest depends most of the times on the expected time to achieve Return On Investment (ROI).

However, a few respondents have identified possible downturns of this design if certain conditions will not be fulfilled. For instance, respondents #1, #2,#3, #5, #8 have mentioned that benefits exploitation occurs as long as pickup points are automatized. Moreover, respondent #2 has argued that UAVs and pickup points would have to transport and host respectively either larger or equivalent amount of parcels as current distribution systems in order to recreate high delivery density. A further risk is the phenomenon of duplication of facilities that can cause severe effects to urban land use (respondents #1, #2). Instead, despite a general favourable opinion, respondent #3 has warned about possible negative effects on customer's service level experience. Actually, effect of faster parcel deliveries could be nullified by forcing end-consumers' complaint to still go to pickup points locations for parcel collection, which would not change the situation compared with road parcel delivery services.
Finally, respondents #6 and #11 have offered a different interpretation of an eventual implementation of pickup points design with UAVs. Respondent #6 expects that UAVs will transport freight from cross-doc areas or main Distribution Centres (DCs) to Urban Distribution Centres (UDCs). These last facilities will assume the function of pickup point, which is an unlike vision concerning the use of UDCs compared to the one mentioned in the paragraph concerning "carrier delivery" and "last-mile delivery" designs. Instead, respondent #11 thinks that the application of UAVs for B2C parcel deliveries will radically modify the pickup points concept. Based on the assumption that UAVs will increase their role in urban society, he expects that pickup points design will converge towards a "last-mile delivery" design, as these parcel reception facilities will be integrated with urban architecture in the form of either stations or balconies whose function will be to allow take-off and landing operations of UAVs.

8.3 Results concerning Supply Chain for perishable products and reverse Supply Chain

This section of the research project will show the results concerning both Supply Chain for perishable products and reverse Supply Chain. Despite these topics have been presented in separated sections in the chapter of the literature review, the student has decided to merge them, as from the interviewing activity it has been possible to gather a relatively limited amount of details.

Regarding the application of UAVs as vehicles for delivery of perishable products, despite several respondents have provided generic information, outcomes still result quite valuable and interesting. Actually, respondents with expertise in UAVs have been sources of information concerning either potential or limit of these vehicles in performing such activity. Instead, respondents #3, #5, #7 have provided information related to significant aspects to consider in performing ready-made meals and grocery delivery operations.

In general, the majority of the respondents (independently from the type) have considered feasible to perform delivery operations of perishable products by means of UAVs. However, respondents #6, #9, #11 have highlighted that possible limitations can raise due to policies for labour safeguard of food carriers and social value of doing grocery respectively.

Large part of the respondents and especially respondents #3, #5, #7 (with expertise in freight logistics and distribution and food retailing) believe that UAVs will be able to carry the weight of an average grocery or ready-made meal parcel. Actually, according to company's records, respondent #7 has told that a grocery online order weight on average 10 kg and respondents #3, #5 have argued that a usual meal delivery order weights less than 5 kg. Using these weights as basis of reasoning, respondents #4, #6, #8, #10, #11 (owning expertise about UAVs) have confirmed UAVs' ability to transport parcels within this range of weight, but they have also argued that current propulsion systems' inefficiencies do not allow performing operations with these weights for sufficient time span.

Then, respondents #3, #4, #5, #7, #8 believe that delivery of grocery and ready-made meals by means of UAVs will follow the same regulations that are implemented in road freight transport. Therefore, UAVs will have to be equipped with temperature maintenance and control measures (e.g. poly-boxes, insulating cardboard, ice packs) that are usually implemented in road parcel delivery service. Adoption of these basic solutions is favoured by the relatively limited operational range of these deliveries, possibility to exploit direct-line flight, avoidance of urban road traffic and implementation of direct delivery to end-customers' address because (as end-customers either eat or store in short time meals and grocery respectively). Due to the aforementioned reasons, respondents believe that it would not be necessary to do significant investments for equipment. Nevertheless, grocery delivery operations require careful choices. Actually, respondents #3, #4, #5, #7 have highlighted the risk to include frozen foods, as transport of this product class is demanding in terms of temperature and control measures due to the high sensitivity to temperature variations. Frozen foods need storage and transport conditions in a temperature range between -16 -18 °C and it is necessary to adopt sophisticated equipment to achieve and maintain such temperature conditions conduct of operations. This event can significantly increase energy consumption level compared to transport of non-perishable or fresh food products, as these last ones are less demanding in terms of temperature maintenance and control. Furthermore, risk related to implementation insufficient measurers is to observe phenomenon of product quality decay that can affect food merely from an aesthetic perspective, but it could also cause of a potential safety issue (e.g. customers consume rotten food).

According to respondents #3, #5, #7, qualitative status of the parcel at the time of reception is a very critical feature in ready-made meal and grocery delivery service. Actually, these respondents have argued that poor attention on this aspect risks to compromise customer' satisfaction, which can lead to customer's decision to not use again the service. Therefore, in order to maintain or even improve profitability of the service, they think that it would be important that UAVs could guarantee an optimal performance under this operational aspect.

Instead, concerning possible modalities for conduct of reverse Supply Chain operations by means of UAVs, this is the aspect where respondents have provided less information. Actually, the majority of respondents (and especially respondents #3, #5, #7 with expertise in freight logistics and distribution) have argued that product returns management is still a major issue for the industry. Actually, respondents #3, #5, #7 have mentioned that, despite logistics and service providers usually perform this service for free, they implement such strategy only to avoid end-customers' dissatisfaction. The same three respondents have suggested that from a logistics and distribution provider's perspective, the best option for product returns management is the pickup points design. Actually, this option usually gives more freedom to end-customers (no need to wait operator) whilst delivery operators do not have to visit multiple and differently located end-customers' addresses that could affect negatively entire conduct of operations, as it will probably be more complex to integrate and coordinate forward and reverse Supply Chain flows.

8.4 Results about UAVs' urban mobility policies and freight transport regulation

Every subject willing to conduct commercial operations have to fulfil and respect a set of heterogeneous norms, rules and policies in order to be legally entitled to perform business activity. The next lines will present the results coming from respondents' interviews concerning the possible measures that regulative authorities (urban and higher-level) could implement in order to norm B2C parcel delivery commercial activity in urban areas performed by means of UAVs.

A first interesting outcome emerging from respondents' interviews is that all of them agree that regulative authorities (independently from the type) would probably play a key role in defining the modalities through which it would be possible to conduct B2C parcel delivery operations by means of UAVs within urban air space. Actually, although these regulative authorities differ in terms of decision-making power, the respondents have argued that both have the common goal to enable and favour conduct commercial operations in public space granted that subjects conducting commercial operations fulfil and respect certain legal requirements in order to ensure a minimum level of public safety. Although they have been considered both significant subjects, large part of respondents' information related to possible measures that higher-level regulative authorities (e.g. EU or national governments) can implement in order to norm UAVs application within urban context. Instead, respondents have given less details about the urban authorities' role, assigning them more a control and monitoring function of UAVs' operations within the respective urban air space.

General idea among respondents is that higher-level regulative authorities will be the subjects responsible to create the regulative framework containing rules, norms and standards that have to be fulfilled and respected in order to apply UAVs for exploitation of B2C parcel delivery operations within urban air space. For instance, respondent #6 has argued that European higher-level regulative authorities, such as the European Aviation Safety Agency (EASA), will norm commercial applications of UAVs by means of a set of reliability requirements that will vary according to the specific mission that UAVs have to perform. Therefore, he expects that a clear classification of commercial UAVs will be created. However, respondent #4, #6, #9, #11 expects that higher-level regulative authorities will not operate through a strict application of same regulation in all the European urban areas, as the specific environmental context where operation occur is an important variable to take into account. For instance, according to respondent #6, UAVs regulations will be based on the Acceptable Means of Compliance (AMC) principle that makes possible to set up a set of norms that can vary within a defined range of values. Then, urban authorities will be the subjects responsible to choose the most suitable values within the range that fits the most with the specific urban context. Aim of AMC is to ensure the equivalent reliability and safety requirements across heterogeneous urban spaces.

Going in detail about aspects of urban B2C parcel delivery operations performed by means of UAVs that can be normed by higher-level regulative authorities, several respondents (#1, #2, #3, #4, #8, #9, #10, #11) expect that both flight altitude and transport capacity will undergo a careful regulation, as these two aspects have been considered elements strongly related to public safety. Respondents #8, #9, #10, #11(with expertise in UAVs) have also provided approximate indications concerning the possible flight altitude for commercial UAVs in urban air space. They estimate that UAVs could operate in a range between 150 and 200 meters, as these flight altitudes are considered able to satisfy both operational perspective (containment of energy consumption level because air is not rarefied) and public safety (acceptable level of risk in case of crash from this range of flight altitude).
Respondents #1, #2, #3, #6, #8 expect that higher-level regulative authorities will require the implementation of buffer zones and no-fly zones in every urban area where these unmanned aircrafts are going to conduct commercial operations. The same respondents think that urban authorities will have the task to identify both suitable spaces for buffer zones and sensitive areas that need flight interdictions. Common reason provided by respondent to justify such approach is that urban authorities have better knowledge about the specific urban space.
Interesting insight provided by respondents #6, #8, #11concerns the absence of compulsory flight path for UAVs in urban air space. They think that UAVs will be free to move across the entire urban air space, with exclusion of no-fly zones and flight altitude obligations. Actually, respondent #6 has argued that application of pre-defined flight paths, as it has occurred in the past for manned civil air traffic, has proved to be an ineffective regulative measure because it has endangered to cause inefficiencies in terms of air traffic and costs as well.

Respondents #2, #4, #6, #8, #9, #10, #11 expect that higher-level regulative authorities will define a set of norms, standards or certifications concerning UAVs’ technological features. For instance, respondents #4, #6, #8, #9, #10, #11 have argued that UAVs’ materials and components would probably have to own and fulfil certain certification requirements, such as CE trademark, in order to prove that they have a sufficient level of reliability to perform commercial operations in public space. However, these certifications will probably involve only components that would be considered as highly sensitive elements. The respondents have cited propulsion systems, autonomous control systems and Detect-Sense-Avoid (DSA) systems, as the fundamental technological features that have to prove to be sufficiently reliable and effective to perform operation within urban context whilst ensuring public safe as well.
For instance, reason to apply certification/standards to propulsion systems is their scarce level of reliability. Actually, current Li-Po batteries do not result suitable for commercial application, as they present high risk of flammability in case of damages (respondent #9). Then, respondents #6, #8, #9, #10 have argued that the unreliable re-charging process and too short life-cycle are further reasons to norm batteries, as negative effects would be observed at operational, safety and environmental levels.
About autonomous control systems, GPS will be the basic technology, but higher-degree regulative authorities will probably require the compulsory integration of a redundant ICT infrastructures solution in order to cover the current gap of GPS and thus achieve sufficient reliability (respondents #6, #8, #9, #10, #11). Furthermore, they have also argued that a strict regulation of ICT infrastructures will be necessary, as UAVs are expected to perform B2C parcel delivery operation autonomously and in Beyond Visual Line Of Sight (BVLOS) modality as well. These conditions will be a completely new way to manage operations and respondents think that a careful regulation

is needed in order to have sufficiently reliable communication channels that ensure effective and constant control of UAVs within a large set of circumstances. Furthermore, the same respondents (#6, #8, #9, #10, #11) have suggested that higher-level regulative authorities could set specific or even encrypted communication frequencies for autonomous UAVs with the aim to prevent any possible jamming phenomenon caused by other telecommunication devices that disturb communications or even hacking attacks.

Concerning eventual regulative measures for propellers design, respondents #4, #10, #11 have highlighted that it could be possible that UAVs will have present specific configurations in order to be legally authorised to perform B2C parcel delivery operations in urban areas. Actually, respondents #10, #11 have argued that UAVs (specifically rotors) will have to own at least 6 propellers because this configuration offers an higher successful rate concerning UAVs' ability of managing flight operations even in case of emergency (e.g. damages). Instead, respondents have expressed different opinion concerning eventual other safety measures, such as parachute or air bag systems. For instance, this option is not supported by respondents #4, #10, as they think that these solutions would be ineffective from a technical perspective, as they will subtract space and increase overall vehicle's weight that can compromise operations. However, respondent #6, #10, #11 have highlighted that the most important characteristic will be to ensure that the safety measures have to be either complete independent from the main power source or even rely on a non-electronic trigger mechanisms for its activation. Actually, only in this way they think that reliability can be achieved.

From the respondents' interviews, the modality through which parcel reception can be performed has resulted ambiguous and it has been source of general concern, as they do not have clear how collection of parcel from UAV can occurs. Actually, respondents has considered parcel reception as a critical event, since it corresponds to the moment when autonomous machine interacts directly with end-consumers. Respondents believe that higher-level regulative authorities will norm modality for parcel reception based on safety principle, which favours the implementation of the solution that will provide end-customers the highest level of safety. Despite the undefined situation, respondent expect that higher-level regulative authorities will hardly allow take-off and landing operations in every free public space, as it will be considered as a highly risky situation. The outcome coming from respondents' interviews is that there is still uncertainty. A few respondents have suggested that regulations could go towards the creation of dedicated areas for UAVs operations. For instance, respondents #1, #5, #6, #8, #11 have argued that "pickup point" design could offer a solution to the issues of parcel reception, as they create safe areas for UAVs operations and minimise interactions between machine and human, which enhance further the safety level. Instead, respondent #10 has conducted a few tests with his UAV to drop and pickup parcel by means of a mechanism based on application of a system of hooks. Although the interesting results offered by the tests, he has decided to interrupt tests because, as entrepreneur, the absence of higher-level regulative authorities' clear vision about possible norms concerning this topic prevents any possible serious investment. Other respondents (#4, #6, #8, #11) have also mentioned this conflicting situation, where on one side UAVs industry is willing to invest, but at the same time it feel the constraints for the sometimes quite slow, complex and sometimes too cautious bureaucratic higher-level regulative authorities' approach that limit technological progress.

Concerning eventual regulative measures to address mobility and environmental issues afflicting urban areas, the interviews have provided an interesting result. Actually, the integration of UAVs in freight logistics and distribution networks to exploit B2C parcel deliveries has been considered by

respondents as already a measure that aim to improve mobility and environment of urban areas. Respondents #1, #3, #5, #6, #7, #10, #11 have argued that UAVs can offer the advantage to both partially lighten the pressure that oppresses urban road infrastructures, which gives benefits in terms of smoother traffic flows, and simultaneously they contribute to make freight transport industry more sustainable thanks in terms of GHG emissions thanks to adoption of electric propulsion systems. However, a few respondents (#8, #9, #10, #11) have warned about possible negative side effects if inefficient propulsion systems are implemented in large scale on UAVs performing B2C parcel deliveries. Actually, the short lifetime of batteries and the insufficiently reliable recharging cycle of Li-Po batteries (implemented on large part of UAVs) risk to cause significant increase of waste production, which could further worsen situation because recycling process of these components can become even more expensive.
Instead, about the issue of noise pollution in urban areas, both logistics and distribution professionals (respondent #3, #5) and respondents #8, #10, #11 (with expertise in UAVs) believe that UAVs can also offer improvements under this perspective compared to road transport. Actually, air transport combined with use of electric propulsion systems have been mentioned as sufficient measures to discretely lower noise exposure level. Moreover, use of more silent vehicles could give the opportunity to extend time span of operations even during night. Effects of this possible extension of conduct of operations could help to lower even more the noise exposure (as deliveries are spread across a longer time span) and simultaneously enable B2C parcel delivery providers to optimise operations schedules (with consequent positive effects on urban mobility).

Respondents #4, #6, #8, #9, #10, #11 have highlighted that introduction of autonomous UAVs in freight logistics and distribution industry would not limit its effects to a radical change from an operational perspective, but it could significantly affect labour policy and regulation as well. They think that conduct of B2C parcel delivery operations through these autonomous machines would ask to reinvent the professional figure of parcel delivery operator. Actually, these respondents have argued that the new professional figure of parcel delivery operator will need to own certain knowledge and skills, as he will have to interact and manage with an advanced autonomous machine. Therefore, as it currently occurs for remotely control UAVs, the respondent have suggested higher-level regulative authorities will develop certified trainings in order to form this new professional figure. However, respondent #6 has warned about possible rise of socio-political conflicts caused by an eventual switch of freight logistics and distribution industry from human-based towards automatization of parcel delivery operations, as labour rights and safeguard of several workers can undergo to severe threaten, which is against the fundamental principle of rights for a job supported by higher-level regulative authorities.

As previously mentioned in the relative chapter of the literature review, urban authorities are subjects that play a role in defining mobility of urban areas, as they can manage and control traffic flows within urban space. General idea among the respondents is that these local regulative authorities can give a significant contribution to favour an eventual optimal integration of UAVs exploiting urban B2C parcel delivery operations. Respondents #1, #2, #4 #6, #10, #11 believe that urban authorities should have an active role in the decision-making processes to regulate UAVs in urban context together with higher-level regulative authorities. Actually, the same respondents have mentioned collaboration, cooperation and coordination among urban mobility stakeholders (freight logistics and distribution providers – urban authorities – higher-level regulative authorities) as necessary and fundamental conditions to achieve a comprehensive and effective regulative framework for UAVs exploiting commercial operations in urban context and this collaboration can occur at different levels. For instance, optimal decisions-making process concerning number and location of either automatized pickup points or UDCs would need collaboration between urban authorities and freight logistics and distribution providers, as risks of further erosion of urban land and duplication of facilities can be minimised. Large part of the respondents (#1, #2, #4, #6, #8, #9, #10, #11) has argued that control and monitoring activity of autonomous UAVs performing parcel delivery operations in urban areas is an additional aspect that need collaboration and coordination between regulative authorities and freight logistics and distribution providers. These respondents expect that supervision of UAVs will probably occur in a fashion similar to the one adopted in civil manned aviation. It means that control and monitoring of UAVs traffic flows in urban air space will involve the different UAVs owners and a third independent authority. European higher-level regulative authorities will probably have the task to establish an Unmanned Aviation Agency (UAA) that could place several local offices in urban areas where autonomous UAVs perform parcel delivery operations. UAA would have the additional tasks to assess infringements and assign relative sanctions in case UAVs operations do not occur according to rules and to either integrate or coordinate UAVs traffic flows with manned air traffic.

Finally, despite the scarce quantity, respondents' interviews have provided a few information concerning possible norms and rules about both conduct of B2C parcel delivery operations if perishable products are involved and management of product returns. As example, respondents #3, #4, #5, #7, #8 believe that regulations for transport of perishable products (e.g. fresh and frozen foods, ready-made meals) will be the same as the ones currently applied in road freight transport, as operations have to occur in a way that minimises potential rise of risk for public health. Instead, respondents #2, #3, #5 have argued that regulations concerning reverse Supply Chain relates more to processes that occur after product returns have been collected. Management of returns from end-customers to facilities is usually related to make operations either more efficient or more effective, which does not relate much with regulations and this idea is valid independently from the product category considered.

9. Discussion and Conclusions

This chapter contains the conjectures that the master student has developed based on the outcomes of respondents' interviews. Moreover, conferences in Brussels (B) and in Bristol (UK) have been additional sources of information that the student has used to develop part of the conclusions of this research project.

As brief introduction of this chapter, I would like to present some generic information that can give an idea about the current situation concerning UAVs. From the conference in Bristol (about commercial application of UAVs), it has been possible to verify how these remotely piloted unmanned aircrafts have found applications across various industries in the last years. This increasing demand for use of UAVs from professionals has forced decision-making authorities to look at these unmanned class of vehicles with more attention. Actually, by attending the conference hold in Brussels, it has been possible to notice how European Union authorities have become more conscious of the potential disruptive effects that such innovative class of aircrafts could exercise on several aspects of modern life. A proof of this higher level of involvement of regulators is the Notice of Proposed Amendment (NPA) 2017-05 (A) that has recently released by EASA (information partially mentioned by Olivier Fontaine during his interview). Aim of this document is to develop, after an open discussion and a subsequent decision-making process, a regulatory framework for conduct of operations by means of UAVs with a maximum take-off mass lower or equal to 150 kg valid across all European member states. Nevertheless, a possible application of UAVs for B2C parcel delivery operations within urban context is a topic that is considered sensitive and poor measures have been done about it. Therefore, the following conclusions concerning engineering and technological features have to be understood as assumptions based on an elaboration process of the gathered information.

9.1 Conclusions concerning UAVs' technological features

From an analysis of the results of respondents' interviews, it is possible to draw certain conclusions about UAVs' technological features. Among propellers design, fixed wing is the less suitable option for conduct of B2C parcel delivery operations in urban context, as it is not possible to perform vertical take-off and landing. VTOL has been recognised as fundamental technical feature to operate in complex environments, such as modern urban air space. Information gathered through interviews suggest that a most suitable and effective use of fixed wing design concerns the conduct of air cargo operations, as it would be possible to exploit the better airworthiness level, which allows travelling for long distances whilst containing energy consumption level.
Instead, VTOL ability and a higher degree of control of flight manoeuvres are strong reasons supporting the choice of either rotors or convertibles UAVs propellers designs to perform urban B2C parcel deliveries. The worst features in terms of airworthiness level and relative risk of higher energy consumption level have been considered marginal limitations, as the issue of limited operational endurance is mainly caused by propulsion systems' inefficiencies rather than propellers design and average B2C parcel deliveries occur within a short-medium distance range. Convertible UAVs combine the two strong points of the other two designs (good airworthiness level and VTOL ability), but the several moveable components make the vehicle structure more complex and delicate. However, the master student believes that in certain circumstances convertible UAVs can be a feasible option to perform B2C parcel delivery in urban context as well (more details in section 9.2). Therefore, rotors have resulted being the most eligible UAVs' propellers design option for the conduct B2C parcel deliveries in urban areas.

Respondents' interviews have not provided information to identify a precise UAVs' size, but they suggest that vehicle's size should be sufficient to achieve a transport capacity for parcels with weight between 2,5 and 15-20 kilograms in order to perform B2C parcel deliveries. Therefore, transport capacity is a more relevant feature, as it has a role in defining operational strategy. According to respondents with UAVs expertise, problem with propulsion systems is not much related to an eventual insufficient power generation to sustain weight of the payload, but instead it concerns the insufficient performance in terms of endurance to perform parcel delivery operations due to propulsion systems' inefficiencies and sensitivity to weight variations. Despite neither respondents' interviews nor conferences have clearly addressed this issue, the master student believes that transport capacity affects a further significant operational aspect. Actually, transport capacity can partially define the possibility to perform multiple parcel deliveries simultaneously, which is an element of strategic value because it contributes to determine both suitability and effectiveness and efficiency of operations offered by implementing UAVs in a specific freight logistics and distribution network design.

It has been assessed from the interviews that the UAVs' technological feature of propulsion system is clearly a fundamental issue, as it affects and at the same time is affected by other factors. First, propulsion system is the technological component that has to provide sufficient performance in terms of power generation and operational endurance in order to perform successfully B2C parcel delivery operations. Therefore, besides efficiency and effectiveness, the most important feature that a propulsion system has to prove to own is reliability, as it is a fundamental condition not only to be able to perform operations, but to guarantee a safety conduct of the same operations as well. Actually, a respondent has warned about risk of inflammable phenomena due to structural sensitivity of current propulsion systems. Besides being a limit from an operational perspective (costs increase), UAVs' propulsion systems present an unreliable recharging process and insufficient life cycle for commercial application like B2C parcel deliveries that can have a negative environmental impact, risk id to observe increase of waste production. Option of internal combustion engines could be suitable in the short run, but it is a choice completely opposite to European higher-level regulative authorities' medium-long term plans, as it has been possible to assess during the conference concerning freight and public mobility held in Brussels. Actually, the goal of the next decades would be to create a more sustainable mobility within the European continent by removing commercial and private vehicles based on fossil fuels and using other ones based on almost zero-carbon emissions technologies. Moreover, besides contrasting climate change, this measure could result financially beneficial for businesses organisations in the medium-long run, as it will shield them from financial price volatility typical of fossil fuels

Going further with the analysis of UAVs' technological features, both conferences and respondents' interviews have confirmed that, besides the novelty concerning the unmanned nature of these vehicles, the use of autonomous vehicles is the factor potentially able to revolutionise the conduct of freight logistics and distribution operations. Actually, UAVs for B2C parcel deliveries (together with certain recent vehicle models released by the automotive industry) will be the first application in real world context of advanced robotics. By conducting respondents' interviews and attending conferences, current commercial applications of UAVs need always direct human control and supervision by means of a control unit and conduct of operations in VLOS modality respectively. These operational conditions will rarely occur within urban B2C parcel delivery context, as the relatively long distances and presence of physical obstacles (e.g. buildings) will require to conduct operations in Beyond Visual Line Of Sight flights (BVLOS) modality that makes more difficult for UAV operator to perform control and supervision activities. Moreover, an eventual integration of cameras to enable UAV operator to perform remotely controlled BVLOS flights has not been considered as sufficient reliable option, as the operator will nor probably receive a sufficiently reliable set of information about field conditions surrounding the UAV. This phenomenon combined with possible gaps in data transfer due to communications delays or signal blind spots make operator's decision-making process more complex with consequent higher probability of accidents and/or crashes occurrence. Moreover, common idea supporting the use of autonomous control systems is that highly automatized processes are generally correlated to performances with higher degree of reliability thanks to high standardisation and control of operations (even in situations of emergency), as supported by Bendea et al. (2008) as well.
An additional reason for application of autonomous UAVs for exploitation of B2C parcel deliveries (especially supported by respondents with expertise in freight logistics and distribution) is the opportunity to achieve consistent savings at level of a critical costs feature of today's freight logistics and distribution industry: human workforce. Actually, it is the only operational area where evident changes have not occurred during years, as it has been always necessary to hire a human operator to drive delivery vans.

With the available information collected coming from respondents' interviews and conferences, the master student cannot draw detailed conclusions about the set of most suitable sensors to install on autonomous UAVs. He can only assert that sensors are fundamental technological components, as both type of sensor and the quantity and quality of data that they can provide have a direct influence on UAVs' autonomous control systems decision-making process. However, with the information in his possession, the author can give a few suggestions about which sensors could be integrated on UAVs performing B2C parcel deliveries. For instance, he expects that common sensors present in remotely controlled UVAs will be also included in autonomous UAVs, as they measure basic parameters for conduct flight operations (e.g. altimeter and anemometer for wind speed). Nevertheless, the "autonomous" factor will need the setup of specific extra sensors. Based on a few respondents' opinion, cameras with either optical, sonar or laser technologies will be needed in order to perform detect-sense-avoid activity of external obstacles. Moreover, Concerning cameras, the master student believes that they are important sensors for autonomous UAVs for an additional reason. Cameras could play an important role not only because they could enable UAV operator to have sufficient filed vision to manage operations in case of emergency even in BVLOS flight modality, but they can also be important for insurance policies. Actually, "unmanned" and "autonomous" characteristics are new variables that will probably affect insurance companies in performing a responsibility assessment processes. Therefore, this project expects that cameras and black boxes (these last ones commonly used in other commercial vehicles) will be compulsory equipment by law.

Finally, this research project has assessed the critical role of ICT infrastructures for the conduct of operations by means of autonomous UAVs. Actually, respondents' interviews have clearly asserted that ICT infrastructures have a strong correlation with reliability level of operations, as this technological feature has to guarantee constant and effective communication channel for data sharing between both UAV-UAV and UAV-GCS. Furthermore, the research project has confirmed that GPS will form the backbone of the ICT infrastructure for autonomous UAVs, but its sensitivity to environmental phenomena (e.g. solar wind, sub-optimal meteorological conditions) cause significant inefficiencies in the conduct of operations. It is reasonable to expect that such relatively scarce level of reliability will not be accepted in the event UAVs' operations will occur in urban context, as presence of multiple externalities will require UAVs to conduct operation with high level of precision. Therefore, it will be necessary to identify and integrate an additional measure to create reliable and secured ICT infrastructures. Given that higher-level regulative authorities could express their influence on such technological feature (more details in section 9.3), the author believes that business organisations will have a margin of manoeuvre concerning the form of this additional ICT infrastructure. Together with other factors, it will offer opportunity to develop different freight logistics and distribution network designs (see section 9.2).

9.2 Conclusions about UAVs' freight logistics and distribution network designs

This section includes the descriptions with the relative tables (Table 5,6,7,8, 9) of the possible freight logistics and distribution network designs for autonomous UAVs performing B2C parcel deliveries in urban context that the student has developed through an analytical process of the information gathered during the entire conduct of the research project. Overall, the interviews' results have proved that UAVs could be suitable vehicles for B2C parcel delivery. However, propulsion system's endurance, form of the additional ICT infrastructure and product category are factors that affect the structure of the freight logistics and distribution network design. Here below, it is possible to find the different options of freight logistics and distribution networks design that has been developed by the author.

9.2.1 Manufacturer storage with direct UAV parcel delivery

This design could result a feasible and interesting option only if the term manufacturer is interpreted as shop offering the service of ready-made meals delivery. However, the author want to clarify that in his opinion not all shops offering such service are eligible to implement this design. From the information of respondents #3 and #7 (with experience in food delivery business), ready-made meals delivery is a business extremely susceptible to certain features, such as quality appearance of parcel and timing of delivery, compared to other products. Poor attention to these aspects can have drastic effects on customer's perception of quality service level. Therefore, the author has identified fast-food restaurant chains (e.g. McDonald's, Burger King®, KFC, Pizza Hut and similar) as the shop category that owns the right characteristics to benefit from the implementation of this design. Actually, they usually operate in a Make-To-Order fashion rather than Build-To-Order (as instead it occurs in traditional restaurants), which means that meals can be prepared through highly standardised processes by trained personnel and these conditions make food preparation extremely fast as well. Besides the large majority of these fast food restaurants chains offer the opportunity to consume meals at the same shop, they usually sell meals in wrapped format in order to allow take-away consumption as well. In author's opinion, this way of managing operations would fit extremely well in case of meal online sale. In addition, as suggested by respondents #3, #7, an eventual delivery of ready-made meals performed by means of UAVs will need the implementation of basic solution for temperature maintenance and control during transportation. The author believes that such logistics and distribution network for ready-made meal delivery by means of UAVs will also offer the opportunity to increase fast-food restaurants chains' customers base, as nowadays it enable people to avoid traveling to physical shop with consequent absence of time and transport costs due to urban traffic.

However, based on interviews' results, the operational features of parcel reception modality and product returns management remain undefined. Master student's idea is that end-customers should be reached at their address. Identification of their precise geographical position could occur by matching GPS technology with mobile phone ICT network. An eventual practice to manage product returns could be that end-customers verify if parcel corresponds to the order and then give a command to UAV (maybe triggered by smartphone application or other physical mechanism set up on the same vehicle) to go back to the shop, which corresponds to starting location of operations. In general, fast-food restaurants chains present a network of shops in large urban areas. This situation would offer a single shop to perform ready-made meals deliveries within a relatively limited operation area, but overall it enables the fast-food restaurants chain to serve customers spread across a larger area. Assuming that only a marginal number of customers has a high fidelity level for a specific brand of fast-food chain, the majority of customers usually eats on occasional basis from different brands. Therefore, the student does not believe that offering UAV ready-made meal delivery service by means of membership is a suitable option. Instead, the service could be offered under payment of a fee otherwise free shipment if customer's bill overcomes a certain amount of money, which respondents' #3, #7 have mentioned as common practices accepted by end-customers for such category of delivery service. However, respondent #7 and part of the literature (Van Duin et al., 2016; Russo and Comi, 2010) suggest that business organisations should have control of time windows for parcel deliveries, as they can achieve a high customer service level thanks to an optimal management and coordination of operations occurring both at physical shop and at B2C ready-made meal deliveries.

	Manufacturer storage with direct UAV parcel delivery
UAVs' propellers design	Rotors
Product category	Ready-made meals, but fast food meals can be extremely suitable due to standardised production and sale format
Business organisation	Interesting solution for restaurants and especially for fast food restaurant chains
Inventory costs	For fast food restaurants chains, no significant changes are expected, as they operate with high level of product turnover that requires already high level of inventory
Facilities costs	Fast food restaurants chains will not undergo relevant changes, as they usually own several shops and sufficient availability of workforce Need to train/hire employees that are going to be responsible of UAVs
Transport costs	New Supply Chain costs feature for fast food restaurants chains, as they have never offered ready-made meal delivery service
ICT costs	Investments in online sale platform (e.g. website, smartphone application) Additional ICT infrastructure has to reach end-customers, but how the service is offered affects choice
Product returns management	Critical operational aspect, as returns in food category are very difficult or impossible to be re-sold in order to recover partially extra-expenses Main reasons of failures are mistakes during parcel assembling and/or end-customer not present at time/location of delivery Risk minimisation is through ICT infrastructure investments and better management of parcel assembling operations
Additional notes	Not defined yet is UAVs delivery service will be offered to all customers or only under membership

Table 5: key features of "Manufacturer storage with UAV direct parcel delivery" design.

9.2.2 Storage at Distribution Centre (DC) with direct UAV parcel delivery

As argued in the relative section of the literature review chapter, respondents have argued that main Distribution Centres (DCs) are logistics facilities that have found large and successful application among E-retailers, as they give the opportunity to achieve high level of freight consolidation with consequent benefits in terms of facilities and inventory costs. A similar structure is implemented by large food retail chains as well, since they can have large DCs serving a network of smaller local shops or they can build a few stores of size sufficiently large (e.g. hypermarkets) to achieve freight consolidation level similar to main DC.

The author believes that both E-retailers and large food retail chain can find this freight logistics and distribution network solution. However, an important to implement such design has been done: UAVs' propulsion systems must have made considerable progress in operational efficiency, which in consequence determines higher endurance level. Given that condition, UAVs' B2C parcel delivery operations will start and end to main Distribution Centres (DCs). Both rotors and convertible UAVs could be implemented in this freight logistics and distribution network design (thanks to the higher endurance level), but the second ones could be more suitable thanks to their better airworthiness feature, which can favour reduction of transport costs. Moreover, convertible UAVs would offer the benefit to extend area of B2C parcel delivery operations compare to rotors because, as mentioned in the relative section of the literature review chapter, good airworthiness level makes possible to achieve better performances in terms of both flight range and flight speed.

Concerning the delivery of grocery, which is an activity that includes possible presence of perishable food items (e.g. meat, fish, refrigerated food), use of poly-boxes and ice packs is needed in order to maintain a sufficient level of product quality during transport and an eventual wait until end-customer collects the parcel. The inclusion of frozen foods is an option not recommended by the author, as basic temperature maintenance and control measures will not be sufficient anymore to preserve product quality.

Concerning facilities costs, the author expect that they will probably assume a marginal role, as they might concern only an automatization line for loading parcel on UAVs and/or eventual training of personnel.

ICT infrastructures for this B2C parcel delivery network will be based on GPS technology and the supporting ICT measure to integrate with GPS in order to ensure reliable conduct of operations could be a solution based on "mashing network" communication model (presented in Table 1 of this document). This condition could be achieved by connecting UAVs with end-customer's mobile signal or more interestingly by implementing a similar solution as suggested by respondent #8. Actually, it offers three potential benefits. First, it creates a platform where UAVs can either land or hover in order to drop parcel and it could be possible to integrate equipment, such as solar panels, to perform the function of recharging station as well. Then, author's third benefit is that these UAVs platforms could offer E-retailers and large food retail chains the opportunity to speed up the process of returning of initial investment by adopting a similar strategy implemented by Amazon in order to become one of their "Prime" members. The strategy consists in offering end-consumers UAVs parcel delivery service without charging service fee under condition of membership payment (time span based). Author's believes also that customers that sustain this initial investment to get access to UAVs parcel delivery service could be more inclined to purchase products through this sale channel in order to exploit the maximum benefits from that initial investment. Finally, use of this UAVs platform could be a feasible and valuable way to manage the issue of product returns. Actually, as UAV drops the parcel, the end-customer can use platform to place parcel that contains products that have to be returned. End-customers could initiate these returns service through either accessing a designated area of company's website or mobile application.

	Storage at Distribution Centre (DC) with direct UAV parcel delivery
UAVs' propellers design	Convertible UAVs
Product category	Food and non-food products (frozen foods excluded due to demanding temperature maintenance and control conditions)
Business organisation	E-retailers and large food retail chains
Inventory costs	Main DC can offer the opportunity to exploit freight consolidation
Facilities costs	Not much relevant, as UAVs will start B2C parcel delivery operations from DC (only need to form UAVs operators) Higher feature in case of food products due to implementation of equipment for temperature maintenance and control
Transport costs	Convertible UAVs could favour a partial reduction of this costs feature
ICT costs	To invest in additional ICT infrastructure based on mashing communication network model If additional ICT infrastructure can be in form of platform, as it would allow conduct of UAVs landing and take-off operations
Product returns management	If additional ICT infrastructure will assume form of UAVs platforms, possible improvements under this operational aspect
Additional notes	Possible higher profitability if service is offered under payment of membership

Table 6: key features of "Storage at Distribution Centre (DC) with direct UAVs parcel delivery".

9.2.3 Storage at Urban Distribution Centre (UDC) with road direct parcel delivery and/or customer pickup

For this design, the assumption is that UAVs' propulsion systems have not made much progress in endurance performance, which prevents to sustain B2C parcel delivery operations for either very large distances or long time span. Therefore, UAVs will not be able to reach end-customers if they start operations from DCs. Instead, UAVs will start operations from either DCs or cross-doc areas and they will deliver freight to one or more Urban Distribution Centres (UDCs). Respondents #6, #11 have not been the only ones to suggest the goodness of this logistics and distribution network design for application of UAVs in parcel delivery operations. Actually, Amazon has recently filed a patent containing detailed information about design and activities of a special class of buildings where its UAVs will be able to land and take-off in order to deliver freight. As these UDCs will be located in within highly densely populated areas, both respondents and Amazon's project have specified that these buildings will have a structure with pronounced vertical development in order to favour an optimal exploitation of urban land and the implementation of one or more UDCs could give the opportunity to maintain sufficient freight consolidation level. The author thinks that both rotors and convertible UAVs could be implemented in such distribution network design, as the distance to travel is shorter compared to perform a direct delivery to end-customer's address. However, the higher airworthiness level of convertible UAVs can generate more lift, which could offer the opportunity to conduct operations with higher transport capacity.

Interesting aspect of this design based on implementation of UDCs concerns the modality to finalise parcel deliveries. According to the author, they can could occur in two different ways that could even implemented simultaneously. In the first one, end-customers' parcels are assembled by the personnel working at the UDC and then they are loaded on different road vehicles equipped with green propulsion system technologies (e.g. electric vans, bikes) that will deliver parcel to end-customer's address. Instead, the other solution would imply to dedicate a portion of UDCs' storage capacity to hold parcels until end-customers will collect them by going to the UDCs. This modality will transform UDCs into pickup points of large dimension.

As this class of buildings is a completely new concept, its implementation will probably require consistent investments in terms of the Supply Chain costs features, especially facilities and ICT infrastructures. However, despite limitations due to formulation of assumptions, the Costs Benefit Analysis (CBA) of Welch (2015) highlights the interesting prospective of implementing this logistics and distribution network design with autonomous UAVs. Actually, from the result of the CBA, this design would outperform conventional road parcel deliveries.

The additional ICT infrastructure supporting GPS to implement in the UDCs design will be based on either cellular or mashing communication models (Table 1), but master student's preference goes for the first option, since UDCs can be considered long-term investments. He believes also that there can be margin for containment of operational costs (especially in facilities and transport costs). For instance, a possible measure to achieve such costs benefits is to integrate secured lockers (e.g. maybe through QR code reader) inside UDC in order to lower level of human workforce. Moreover, if design of the building is optimised, it could be possible to locate lockers in areas that can guarantee end-consumers 24h/7d access in order to collect parcels. However, the author have a few considerations to express. First, he thinks that UDCs design has a marginal application for large food retail chains. Actually, based on information of respondents #3, #5, #7, large food retail chains operate usually through a well-developed network of facilities and an eventual addition of UDCs could cause considerable increase of facilities costs. Furthermore, the integration of pickup point as parcel reception modality would be difficult to exploit because (always according to the same respondents) the majority of people purchasing grocery online would definitely prefer to receive grocery at home.

	Storage at Urban Distribution Centres (UDCs) with road direct parcel delivery and/or customer pickup
UAVs' propellers design	Rotors – Composite UAVs
Product category	Non-food products
Business organisations	E-retailers
Inventory costs	UDCs offer opportunity to exploit freight consolidation
Facilities costs	They can be a relevant costs feature (especially for a single organisation) Unattended pickup points inside UDCs can partially reduce these costs
Transport costs	UAVs will transport freight from DC to UDCs (shorter distance than going to end-customer's address) This costs feature can contained thanks to 3 strategies: - UDCs are located relatively closed to end-customers - Use of green vehicles to perform B2C parcel deliveries - Possible relevant savings if UDCs assume pickup point function
ICT costs	Additional ICT infrastructure (maybe based on cellular communication network model) can be expensive investment
Product returns management	UDCs are the facilities receive and manage product returns Product can be returned through 2 modalities: - Delivery operator collect returns (other than only delivering parcels) - End-customers bring returns directly to UDCs
Additional notes	This design offers the maximum benefits if collaborative strategy is achieved on two levels: - between business organisations (optimisation of financial resources) - between business organisations and urban authorities (optimisation of urban land use) This design needs a considerable UAVs' transport capacity

Table 7: key features of "Storage at Urban Distribution Centres (UDC) with road direct parcel delivery and/or customer pickup" design.

9.2.4 Storage at Distribution Centre (DC) with coordinated UAVs-van last-mile parcel delivery

Here, the assumption is that UAVs' propulsion systems have a scarce endurance level, which offer the opportunity to conduct of B2C parcel delivery operations only within a limited range in terms of area and time span. Although this limitation, the author believes that it would be possible to develop a logistics and distribution network design that includes the use of autonomous UAVs to perform B2C parcel delivery operations. The entire process start from the DC, where it is possible to exploit freight consolidation. Then, UAVs will be involved in the B2Cparcel delivery operations, but they will do it in a completely different modality compared to the previous designs. Actually, this logistics and distribution network design envisages that UAVs will be integrated on delivery vans and will operate in a coordinated fashion with them in perform parcel deliveries. Therefore, vans will not have the only function to transport parcel, but they will also become mobile UAVs' hangars and Ground Control Stations (GCSs). Both traditional delivery operator and autonomous UAVs will perform operations. However, in order to work with autonomous UAVs, the professional figure of parcel delivery operator will undergo certain modifications. Actually, other than performing parcel deliveries, he will also be responsible for planning, coordination, management and control of UAVs' missions. Within the body of literature, Trujillo et al. (2015) have reasoned about this possible design configuration of B2C parcel deliveries by means of autonomous UAVs and they have highlighted that from a mere executor with limited decision-making responsibilities the parcel delivery operator will assume a managerial role. This new professional figure will probably need specific trainings in order to develop capabilities and skills necessary to interact with autonomous machines and perform planning-management-control activities of UAVs. Poor attention concerning these aspects can lower unreliability of operations that by consequence could significantly increase risk of accidents (Trujillo et al., 2015).

However, such freight logistics and distribution design will require certain financial expenses to be implemented. For instance, the master student believes that vans will need to undergo a few modifications at design level, as these mobile GCSs will have to own a sufficient size to host multiple UAVs and parcels simultaneously. In order to contain partially vehicle's size increase, careful choice of UAV design can be measure. Considering the limited operational range of UAVs due to propulsion system's scarce performances in terms of endurance and the need to share van's transport capacity between the same UAVs and parcels, the master student suggests rotors as most suitable option because, as argued by literature and confirmed during respondents' interviews, they offer the advantage of a more compact design.

Finally, investments in ICT infrastructures will probably be a consistent costs feature as well in this logistics and distribution network design. Backbone of the communication infrastructure will be GPS technology and the supporting ICT measure could be based on mashing network communication model (UAVs platforms as solution developed by respondent #8). However, student's doubts concern where to set up this second ICT infrastructure. Actually, he thinks that use of vans as GCSs, which will move across urban space, will require high precision during UAVs' operations. Therefore, the author thinks this additional ICT infrastructure measure has to be present both on vans and at final destinations of deliveries. Moreover, importance to apply these platforms is also to create a take-off and landing area for the UAVs (as previously mentioned), but it is important to assess if the manufacturing process will makes possible to build platforms of sufficiently contained dimensions to fit with van dimensions. If it is feasible, setup of UAVs' platforms with relative UAVs parcel delivery service could be offered under payment of a membership, which could lead customers to purchase more products through this channel, with consequent better features of ROI for both end-customers and the company offering this parcel delivery service (e.g. E-retailer or logistics and distribution service provider).

	Storage at Distribution Centre (DC) with coordinated UAVs-van last-mile parcel delivery
UAVs' propellers design	Rotors
Product category	Food and not-food products (excluded frozen items)
Business organisation	E-retailers and large food retail chains
Inventory costs	DCs offer the opportunity to exploit freight consolidation
Facilities costs	Not clear idea about costs for a modified vans and salary of new professional figure of delivery operator
Transport costs	Possible reduction thanks to simultaneous van and UAVs deliveries that would shorten overall travel
ICT costs	Possible relevant costs feature, as the additional ICT infrastructure (maybe based on mashing communication network model) will be integrated both on vans and at customers' address
Product returns management	Optimisation of returns management could be achieved through coordination of vans and UAVs' operations
Additional notes	Possible higher ROI and profitability features if UAVs parcel delivery service is offered under payment of membership

Table 8: key features of "Storage at Distribution Centre (DC) with coordinated UAVs-van last-mile parcel delivery.

9.2.5 Storage at Distribution Centre (DC) with UAVs parcel delivery to automatized pickup points

This last logistics and distribution network design has emerged from respondents' interviews as eventual further option for conduct of urban B2C parcel deliveries by means of autonomous UAVS. An assessment of the prospective application of this design has proved to be a challenging task, as several factors (even not strictly related to operations) can have an influence.
Assumption is that UAVs' propulsion systems offer high performance in terms of endurance, which gives the opportunity to start operations far from end-customers, such as from DCs. Nevertheless, the conduct of operations through a network of pickup points usually enables freight logistics and distribution operators to shorten the average distance of the delivery journey, as it is end-customers' task to cover the last-mile distance up to the pickup points in order to collect their parcels. In addition, it must be considered that these parcel reception facilities are usually of relatively limited

dimensions and common strategy among logistics operators consist in positioning them in public spaces with a high turnout of people, (e.g. train stations, shopping malls). Therefore, the author thinks that rotors are the most suitable UAVs option, since the distance to travel would be shorter and it would be possible to develop more compact vehicle's design. However, as it has emerged clearly from the respondents' interviews, autonomous UAVs could perform parcel delivery operations only with unattended pickup points. To be more precise, these parcel reception facilities have to belong to the unattended category, but they have also to be secured and most importantly highly automatized. Automatization of pickup points has been cited as fundamental measure to achieve costs benefits, especially in terms of facilities costs. Actually, it would be avoided the implementation of attended pickup points with the relative payment of a fee and it could be possible even to delivery parcel to these facilities 24h/7d. However, to build such secured highly automatized unattended parcel reception facilities would probably be a demanding investments for a business organisation, as this type of pickup points is a new concept that has been never implemented before. Instead, concerning transport costs, if on one hand pickup points shorten the parcel delivery journey, on the other number and geographical distribution of these of these facilities can affect positively or negatively this costs feature.

With respect to the previous ones, this design offers a more defined solution to the issue of parcel reception modality. Actually, in the other designs, the implicit assumption was the possibility to create suitable spaces for UAVs' operations through ICT platforms positioned end-customers' location or Urban Distribution Centres. However, possible issues with these design are that not all customers could host at their address such UAVs platforms and possible risk of not identify suitable locations for UDCs for scarcity of space due to urban land use phenomenon together with the considerable investment to build such new concept of facility respectively. Instead, secured highly automatized pickup points could be dedicated areas for UAVs land and take-off operations within urban space whilst the relatively contained dimensions could enable to deal better with the issue of urban land use and ask for a lower investment compared to UDCs.

A network of pickup points could also favour an optimisation of reverse Supply Chain flows management, as these facilities could host returns and the same end-customers will have bring them to such locations. However, investments in ICT infrastructures will be needed, as end-customer has to receive information about in which pickup point location he has to drop parcel and then business organisation has to be informed when it can initiate product returns operations. Altogether, the implementation of a network of automatized pickup points could offer operational benefits, but it can be a demanding measure to sustain for single business organisation. Actually, if the all the aforementioned reasons are considered and the additional issue of a possible minimum dimensional scale for enable conduct of operations through such design, operations, the risk is not to achieve ROI within a sustainable time span. Moreover, based on information gathered through interviewing activity, the author wants to add a few final remarks. First, pickup points has been considered an interesting solution for neither ready-made meals delivery (usually the food is consumed as soon as it is received) nor delivery of grocery (people asking for this service usually prefer or want that delivery occur at their address). Then, end-customers could not perceive either any improvement or difference compared to the same parcel delivery service offered by means of road vehicles, which would make them reluctant to pay an eventual fee just because an autonomous UAV has performed the operation.

	Storage at Distribution Centre (DC) with customer pickup
UAVs' propellers design	Rotors
Product category	Food and non-food products
Business organisation	E-retailers and large food retail chains
Inventory costs	DC offer the opportunity to exploit freight consolidation
Facilities costs	Investment in development of a network of automatized pickup points can be demanding for a single company with possible negative consequences in terms of ROI
Transport costs	Several variables concur to define this costs feature: - Benefits (end-customers cover the last-mile distance of delivery) - Downturns (multiple journeys if UAV transport one parcel at time)
ICT costs	Possible relevant costs feature, as it is needed a high level of order visibility to provide order visibility and perform returns management operations Additional ICT infrastructure (maybe based on mashing communication network model) will be integrated in automatized pickup points
Product returns management	This design can help to achieve good performance in product returns management, as it is possible to use the same pickup points facilities
Additional notes	Investments to make these parcel reception facilities secured, as they will be placed in urban spaces with free-access For maximum benefits, cooperation should occur at two levels: - between businesses and urban authorities to identify the most suitable and feasible locations for pickup points - between businesses to create a shared network of pickup points (minimise single investment for overall maximum benefit) Doubts about customers' willingness to pay for UAV parcel delivery service, as they might not perceive any additional benefits compared to traditional pickup points model (despite UAVs can deliver parcel faster to pickup point)

Table 9: key feature of "Storage at Distribution Centre (DC) with customer pickup" design.

Overall, the various designs that have been presented in this section show how much potentiality there can be in the implementation of autonomous UAVs for conduct of B2C parcel deliveries in urban areas. However, the author's analysis has highlighted that not all the designs can fit in every business context, as factors like product category and UAVs' propulsion system endurance affect partially the choices concerning the freight logistics and distribution network design. According to the author, the differences among the various designs do not limit only to the structure, but they concern also the strategy to follow in order to implement a design. Actually, they can have unlike impact on business organisations' financial resources and on urban environment as well.

Therefore, the master student suggests that the most suitable freight logistics and distribution designs for application of autonomous UAVs for businesses that want to pursuit a strategy based on personal financial resources would be:

- Manufacturer storage with direct delivery
  (for restaurants and especially fast-food restaurant chains)

- Storage at main Distribution Centre (DC) with direct delivery
  (for E-retailers and large food retail chains)

- Storage at Distribution Centre (DC) with coordinate UAVs-van last-mile delivery
  (for E-retailers and large food retail chains)

All these designs would give the opportunity to reach directly end-customers' address thanks to set up of the additional UAVs' ICT infrastructure that will perform also the function of platform for conduct of landing and take-off operations. Moreover, it would be possible to conduct parcel delivery operations even in case of limited UAVs' transport capacity, if the data presented by Welch (2015) about 86 per cent of Amazon's parcels weight around 2,5 kilograms as assumption.
The author believes that direct delivery to end-customer's address can be an extremely desirable modality for both businesses and end-customers. Actually, the former could offer the UAVs parcel delivery service and the relative installation of UAVs' platforms under payment of a membership (based on a certain criterion). Since end-customers have to do this initial investment in order to have access to the delivery service based on use of autonomous UAVs, they could be motivated to favour purchase of products and consequent delivery through this service in order to exploit the maximum benefit from the initial investment for becoming members of the UAVs delivery service. The effects could be seen in terms of better features of sales and profitability performance. Independently from which of the three designs is considered, optimal management of both forward and reverse product flows and thus preservation the overall quality of the service, the author suggests that business organisations should maintain control on time windows for operations, as part of the literature confirms (Van Duin et al., 2016; Russo and Comi, 2010). Moreover, further advantage of these three solutions would probably be the lower impact on urban environment compared to the other designs, as UAVs platforms will be positioned only at end-customers' address and their dimensions will be limited.

Instead, "Storage at Urban Distribution Centres (UDCs) with direct delivery and/or customer pickup" and "Manufacturer/distributor storage with customer pickup" design, which would be suitable only for E-retailers and non-perishable products, would be options more difficult to implement for a single business organisation. According to author's opinion, implementation of

UDCs and automatized pickup points for autonomous UAVs would result extremely demanding in terms of investments (especially physical facilities and ICT infrastructures) up to the point to threaten the possibility to recover the expenses for implementation of such design. Then, UDCs and pickup points will have heavier impact on urban environment due to the size (and maybe number) and number respectively of these logistics facilities. In order to make the implementation of these two designs effective and efficient, the master student believes that collaboration at two different level will be a necessary requirement. Specifically, businesses offering B2C parcel delivery service through autonomous UAVs should develop together a shared network of either UDCs or automatized pickup points. Then, the same businesses should collaborate with urban authorities as well. Actually, these last subjects have been recognised as relevant stakeholders of urban areas, as they are able to affect freight logistics and distribution providers by means of their mobility policies (van Rooijen and Quak, 2014; Witkowski and Kiba-Janiak, 2014). The master student considers this collaborative strategy between businesses and between businesses and urban authorities as a form of Sharing Economy, since it gives the opportunity to create a system that would be more sustainable form economic and environmental perspectives (Heinrichs, 2013). Actually, this strategy would help to avoid facilities duplication phenomenon thanks to optimisation of financial resources (each business has to sustain only a fraction of the overall investment) and urban resources as well (urban authorities' deep knowledge of urban space can help to identify most suitable locations for UDCs and pickup points with consequent benefits in terms of land use).
Moreover, since these two freight logistics and distribution designs aim to recreate high delivery density by means of either UDCs or pickup points, the author believes that businesses will perform operations efficiently only of UAVs will have or will be legally authorised to operate with a higher transport capacity compared with the 2,5 kilograms for the previous three designs.

9.3 Conclusions about possible regulations and urban mobility policies for autonomous UAVs performing B2C parcel deliveries

As the student has been able to understand from both respondents' interviews and conferences, regulative authorities have started to define a framework of norms and rules in order to regulate the various applications (e.g. leisure, commercial) of remotely controlled UAVs. Instead, autonomous UAVs have received very scarce attention until now and a few respondents have asserted to perceive regulative authorities' passive (or even contrasting) attitude on this topic. This situation make difficult to identify a clear guideline whose goal is to regulate commercial applications of autonomous UAVs in urban areas. Nevertheless, thanks to the information gathered during the conduct of this research project, the author is able to provide general conclusions about possible aspects that should be included in a regulative framework for autonomous UAVs performing B2C parcel delivery operation in urban context.

As argued in the relative section of the literature review, it is possible to distinguish two categories of regulative authorities with different roles and powers. From the information gathered during interviews and conferences, the author believes that higher-level regulative authorities will have the role of game-changer, as they own the needed decision-making power to regulate autonomous UAVs performing urban B2C parcel delivery operations. Specifically, the higher-level regulative authorities involved in this normative process will be the European Aviation Safety Agency (EASA), European Parliament and European Commission. Actually, EASA is the agency owning specific knowledge concerning aviation safety and the other two are the main governmental authorities of the European Union (EU). However, how it will explained further on in this section,

higher-level regulative authorities will probably delegate part of regulative decisions and/or activities to urban authorities.
Based on the information coming from respondents' interviews and conferences, the author expects that higher-level regulative authorities will regulate large part of the aspects concerning commercial applications of autonomous UAVs in urban context and they are probably going to do it through application of principle of minimum sufficient level of reliability (typical of aviation environment). As it has occurred for regulation of commercial road vehicles for freight transport, the author expects that higher-level regulative authorities will define various manufacturing certifications and/or standards for vehicle's components and compulsory integration of specific safety measures as well. However, UAVs for B2C parcel deliveries will have to conduct operations autonomously, which is a completely new condition compared to traditional scenarios. Therefore, a specific body of norms that target certain UAVs' specific technological features (e.g. autonomous control system, DSA system) will be necessary, as suggested by Custers (2016) as well.
In order to favour the identification of proper level of reliability for autonomous UAVs performing B2C parcel deliveries in urban areas, the author believes that could be beneficial to adopt the approach proposed by Sevcik and Oh (2008). Rather than tests in controlled environment, higher-level regulative authorities should offer the opportunity to conduct mid-level tests in collaboration and under supervision of urban authorities. Mid-level tests are scaled versions of real world tests whose aim is to collect and subsequently process data of different aspect related to operations in order to identify one or more values that can be define minimum sufficient levels of operational reliability that can be translated in form of certifications and/or standards of reliability for commercial operations. The author support the application of regulative decision-making process, as it will enable to define minimum reliability standards that result specific for these unmanned autonomous aircrafts whilst guaranteeing achievement of Equivalent Level Of Safety (ELOS) at least equivalent to the ones of manned aviation. Similar position is supported by part of the literature as well (Dalamagkidis et al., 2008; Shim et al., 2008; Neubauer, 2007).

Going in more details, the analysis of the respondent's interviews has led to identify a few UAVs' technological features that are going to be normed by higher-level regulative authorities. Due to their relevancy, regulative measures concerning these UAVs' features will have an absolute validity regardless the specific spatial context where autonomous UAVs will perform commercial operations, which means that urban authorities will not able to exercise any influence on them.
First interesting aspect to mention is that rather than vehicle's size, higher-level regulative authorities will have to norm UAVs' transport modality. According to general respondents' opinion, this feature affects both conduct and management of operations, but it is also important because it relates to safety issue. Actually, in situation of emergency, other than owning a design and/or safety measures that aim to minimise damages at time of impact, UAVs should prevent loss of parcel, as if parcel falls, it could be a severe threat for public safety.
Extremely important will be to the setup of the minimum sufficient level of reliability of autonomous control systems and DSA systems. As suggested by many respondents, certifications and/or standards concerning quality and reliability of materials and functionality will be the most probable forms of regulative measures for such UAVs' technological UAVs' features. Therefore, certified autonomous control systems and DSA systems will need to present specific software and components respectively in order to be considered sufficiently reliable for commercial applications. Moreover, based on the information of Oh and Piegl (2013) and Goerzen et al. (2010), the author believes that UAVs' autonomous control system should not include only reliable algorithms for path planning, but higher-level regulative authorities will ask to implement security criteria in the

software. Aim of this measure would be to force the vehicle to perform specific manoeuvres once a situation of emergency has been detected , such as landing in buffer zones (explained later on in within this section).

Additional aspect that will be subject of higher-level regulative authorities' decision-making process, as clearly emerged from respondents' interviews, is UAVs' ICT infrastructures. Actually, they are a fundamental technological feature, as they have to ensure a complete control and monitoring of UAVs during the entire conduct of operations in order to minimise the level of risk. In order to ensure that these communication channels operate effectively while showing sufficient level of reliability for commercial applications, the master student believes that higher-level regulative authorities will define norms aiming to create secured ICT infrastructures for autonomous UAVs. This idea finds support in part of respondents' opinions and in the literature (Custers, 2016; Mancini et al., 2008) as well. Possible measure to protect UAVs' communications channels include to appoint specific range of radio frequencies for autonomous UAVs in order to minimise signal disturbance of other electronic devices or even to set up encrypted ICT infrastructures to prevent issues caused by eventual externalities (e.g. jamming, hacking). However, the author can assert that to setup a common ICT infrastructure is probably the most important regulative measure. Actually, despite the performance level offered by autonomous control system and DSA system installed in a single UAV, the possibility to perform data sharing and integration in order to consequently observe coordination of operations among multiple fleets of autonomous UAVs and relative GCSs has been considered more important, as it would make the entire system more of reliable and effective. For this reason, it would be of critical importance that higher-level regulative authorities define a set of norms concerning autonomous UAVs' infrastructures.
Further technological feature that will undergo higher-level regulative authorities' regulation process is UAVs' propulsion systems. However, certifications and/or standards for this technological feature should not aim only to prove operational reliability. Instead, information gathered during respondents' interviews and the conference organised in Brussels by the European Logistics Platform (ELP) organisation indicate that such regulative measures will aim to develop and implement more sustainable propulsion systems from an environmental perspective. Actually, this is not a specific measure for UAVs, but it is part of project at European level whose goal is the achievement of either low or even zero level of GHG emissions in the next decades. Actually, use of this technological feature has been related to the risk of observing larger waste production (due to short life cycle) and increase of demand for power production, which will just move the problem of pollution from urban areas to power plants.

Despite the possible higher-level regulative authorities' leading role in defining norms and rules concerning commercial applications of autonomous UAVs, lower-level regulative authorities will also have a role in the normative process, which confirms what Ducret (2013) and Dablanc (2007) have asserted about urban authorities' ability to affect urban mobility. Actually, as the student has been able to understand from respondents' interviews and during conferences, higher-level regulative authorities will adopt a more flexible approach in norming certain UAVs' operational aspects, maybe by means of guidelines. Urban authorities will use the guidelines as basis to make final decisions concerning regulative measures for these UAVs' specific operational aspects. Reason to delegate part of regulative powers to urban authorities is supported by a few authors (Clothier et al., 2011; Dalamagkidis et al., 2008) that have recognised the importance of the specific environment where operations occur as factor affecting UAVs' regulation. Therefore, it is reasonable to assign the regulation task of these UAVs' operational aspects related to spatial context

to urban authorities, as they usually have a deeper knowledge of the specific urban space. For instance, higher-level regulative authorities could suggest a range of flight altitude for autonomous UAVs, which Dalamagkidis et al. (2008) expects to be between 120 and 150 meters. However, it will be urban authorities' responsibility to define the most suitable values for the specific spatial context, as cities do not present the same urban architecture.
An additional aspect that will probably need an active participation of urban authorities in order to be regulated concerns the identification and setup of buffer zones across urban areas, which are spaces where UAVs can land in case of situations of emergency (e.g. damages, malfunctions). As argued by part of respondents and during the conferences, set up of buffer zones is a necessary safety measure already applied in commercial applications of remotely controlled UAVs. Therefore, it is reasonable to expect that buffer areas are going to be implemented with autonomous UAVs operating in urban context, as this safety measure has been considered more effective than other options. Actually, according to Bendea et al. (2008), direct UAV operator's intervention in case vehicle experiences a situation of emergency could result ineffective due to possible delays in communications and operator's limited perception of field conditions. Finally, as suggested also by Kückelhaus (2014) and by a few respondents, it would be necessary to create an Unmanned Aviation Agency (equivalent to traditional CAA) whose task will be to perform an objective control and monitoring of UAVs during operation. Moreover, this agency should cooperate with responsible agency for manned aviation in order to integrate and coordinate flight operations within urban air space and thus guarantee safety. The author thinks that higher-level regulative authorities will be responsible to create this control agency of UAVs, but operations will be conducted by local offices in order to guarantee maximum control in each specific areas where UAVs are performing operations.

10. Limitations and Suggestions for further research

In chapter 10, the student lists the major limitations that je has been able to identify for this master thesis project. There can be various reasons for these restrictions, like impossibility to get access to certain data or issues concerning respondents' group. Then, a different section will highlight aspects that this research project has not included, but they could be subjects for further research.

A first limitation of this thesis project can be the relatively restricted variety and number of respondents that have been interviewed. Actually, eleven people form the respondents' group (as shown in Table 6). Furthermore, any proponent belonging higher-level regulative authorities and urban authorities has become a respondent of this research project. Absence of these last categories of respondents has had a certain limiting effect, since during the conduct of interviews they have turned out to have a potential important role in defining the eventual modalities to conduct B2C parcel delivery operations by means of UAVs in urban areas.

Impossibility to either conduct empirical tests (even in small-scale) or use logistics modelling software for implementation of one of the proposed freight logistics and distribution network scenarios for UAVs is an additional limitation because it has prevent to compute a solid and reliable cost-benefit analysis. Actually, managerial reports usually contain either real or forecasted financial performance measurements, such as ROI. However, from the different sources of information for this project, the student has been able to gather very few generic data (e.g. average price of top class UAVs from the main three UAVs' manufacturers) and many others have remained unquantifiable, as other factors express an influence on them. For instance, it will be extremely difficult to assign a reliable cost for a certified autonomous control system or DSA system due to the absence of regulative guidelines and even costs for Urban Distribution Centres and secured automatized pickup points for UAVs are elements extremely difficult to quantify.

Then, due to the limited amount of resources, the student has not been able to include all the variables that he originally planned to investigate on in this master thesis project. These missing aspects could become subjects of future studies. As example, it would be interesting to address the potential effects that the implementation of autonomous UAVs could have on labour policies and safeguard, as common social threat is to experience a drastic reduction of job for people. Actually, unmanned nature and automation will be new variables in the conduct of B2C parcel deliveries, as these operations have traditionally involved human workforce. Moreover, a detailed assessment about changes that the professional figure of parcel delivery operator would probably undergo could be done as well.

Despite end-customers have to cover the “last-mile” distance in order to collect parcels, part of the literature has shown how pickup points design has found general favour among the same of end-customers. However, this occurs when parcel deliveries occur by means of road freight transport vehicles. However, if UAVs will perform parcel deliveries, which have been recognised to shorten time of operations, the student thinks that it could be necessary to assess if end-customers will still accept to use pickup points, as the way to conduct operations has changed. Moreover, it could be useful for business organisations willing to use UAVs to conduct B2C parcel deliveries to investigate among end-customers on what logistics and distribution networks design they prefer and the most accepted and suitable payment format for the UAVs parcel delivery service.

Additional area of interest for academics could also be the effects of using autonomous UAVs on insurance policies. As the student has had the opportunity to observe at the conference in Bristol, a few insurance companies have started to include options for remotely controlled UAVs within their portfolio of insurance policies solutions. However, autonomous UAVs will be an absolute novelty, as they would be one of the first commercial applications of a robotic technology that will perform operations autonomously in public urban spaces. This event can make extremely difficult to assign responsibility in case an accident occurs, as accountability is usually assigned to a person and not to a machine. Research could focus on how to develop possible insurance frameworks for unmanned autonomous vehicles in order to assign responsibility to a specific and legally identifiable subject.

Last, but extremely delicate and complex topic for eventual further research concerns the ethical issue of using autonomous robots. During conduct of operations, these machines will perform autonomous decision-making processes based on specific algorithms formulations. Therefore, it could be valuable to discuss about number, category, level of authority and accountability of the subjects that would have an active role during regulative decision-making process concerning algorithms for autonomous control systems, as these mathematical formulations will define the decisional behaviour of the machines.

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Appendix

Supply Chain costs feature:	Affecting factor:	Effects
Inventory	Distribution network design	Use of large in-transit merge facilities (e.g. Distribution Centres) allows exploitation of freight consolidation thanks to economies of scale Depending on type of pickup point, inventory fragmentation can affect negatively costs
	Product category	In grocery delivery service, possible relevant effects due to: - presence of both product categories - presence of items with high turnover rate - attempt to offer same level of product availability of “Brick and Mortar” system Possible relevant effects for restaurants that offer both ready-made meals delivery and in store
Facilities (buildings and operations)	Distribution network design	Depending on type of pickup points (attended or unattended), costs could vary (Punakivi and Saranen, 2001): - > costs of operations (attended) - > costs of buildings and maintenance (unattended)
	Product category	Sensitivity of perishable products requires to adopt buildings equipped with sophisticated machineries and trained workforce that can cause significant raise of energy consumption and handling costs (Miller, 2016; Tammini et al., 2010; Hus et al., 2007; Punakivi et al., 2001) Conventional restaurants prepare meals based on Make To Order principle (it implies preparation and assembling processes) rather than only assembling as it occurs with Build To Order (Guanasekaran and Ngai, 2005)
Transportation	Distribution network design	Direct delivery to end-customers usually implies longer distance Pickup points can reduce transport costs (last-mile distance is allocated to end-customer) and other benefits depending on pickup points model (e.g. lower rate of delivery failure with consequent less re-deliveries) (Pokharel and Mutha, 2009; Mollenkopft et al., 2007; Prahinski and Kocabasoglu, 2006; Daugherty et al., 2005; Sarkis et al., 2004; Ferrer and Whybark, 2001) Propulsion system technology can partially define these costs Urban mobility policies are exogenous factor that can affect transport costs, as they might influence conduct of operations
	Product category	Perishable products usually need vehicles equipped with temperature maintenance-control measures that increase energy consumption
ICT infrastructures	Distribution network design	Relevant costs feature of freight logistics and distribution industry, but accurate investments can reduce other costs features (Hsu et al., 2007; Taniguchi and Shimamoto, 2004) and improve product returns management (Mollenkopft et al., 2007; Wang et al., 2007; Daugherty et al., 2005; Sarkis et al, 2004)
	Product category	Perishable products can need more sophisticated ICT measures (e.g. Radio Frequencies Identification Devices (RFID)) due to their sensitivity (Montanari, 2008)

Table A1: explanation of the effects caused by either distribution network design or product category on Supply Chain costs features.

		UAVs' technological features		
		Propellers design	Vehicle's size	Propulsion system
Respondent #N°	**Type**			
#1	Academic	n.d**	Expected limited transport capacity (less than traditional road vehicles)	Electric
#2	Academic	n.d.	Expected limited transport capacity (less than traditional road vehicles)	Electric
#3	Professional	n.d.	It affects choice concerning freight distribution network Preferable option is to reach size for simultaneous multiple parcel deliveries	Electric
#4	Professional	Rotors Composite design	Potential transport capacity can reach quite considerable values (his UAV can carry 25 kg payload) Possible legal limitations on transport capacity Possible product discrimination (e.g. base on products value) to avoid unfavourable quantity-costs transport ratio	Electric
#5	Professional	n.d.	Preferable option is to reach size for simultaneous multiple parcel deliveries Possible product discrimination (e.g. based on product value) to avoid unfavourable quantity-costs transport ratio	Electric
#6	Professional	Convertible design	Technical limitations are temporary as technological progress is constant Regulative authorities can be main limiting factor for UAVs' transport capacity	Electric
#7	Professional	n.d.	Based on company's records, a transport capacity of 10-15 kg would be a sufficient to cover the large majority of E-grocery orders	n.d.
#8	Professional	Rotors Convertible design	During certain tests, it has been possible to transport payload from 10 up to 20 kg	Electric
#9	Professional	Convertible design	Regulative authorities can be main limiting factor for UAVs' transport capacity	Electric
#10	Professional	Rotors	Regulative authorities will determine the limit of UAVs' transport capacity Attention must go towards development of UAV's structure that is able to host parcel while ensuring safe flight	Electric

#11	Professional	Rotors (≥6 propellers for safety reason) Fixed wing (for long distance freight transport)	Not precise idea about UAV size/weight Large part of mass-market products can be eligible for UAV transport	Electric

Table A2: results of respondents' interviews about UAVs engineering features (** information not available).

		Technological features		
		UAVs control system	Sensors	ICT infrastructure
Respondent #N°	**Type**			
#1	Academic	Autonomous	n.d.**	n.d.
#2	Academic	Autonomous (factor to achieve costs benefits)	n.d.	Specific UAVs investments are needed, but risk of investments duplications
#3	Professional	Autonomous (factor to achieve costs benefits)	n.d	GPS
#4	Professional	Autonomous	Cameras Standards/Certifications for components	GPS This feature will require consistent investments Necessary for clear distinction between manned and unmanned air traffic
#5	Professional	Autonomous	n.d.	GPS Feature that requires consistent investments, but it can make possible to optimise operations
#6	Professional	Autonomous (possible consequences on labour policy)	Standards/Certifications for components of DSA system	GPS + other ICT infrastructure Shared ICT infrastructures
#7	Professional	Autonomous Parcel delivery is the only activity that can be automatized (parcel disintegration does not allow to do it at inventory level)	Basic measures (e.g. poly-boxes, ice packs) for delivery of grocery and ready-made meals (frozen foods excluded)	n.d.
#8	Professional	Autonomous (factor to achieve costs benefits)	Cameras Standards/Certifications for components of DSA system	GPS needs support of additional technology to reach sufficient level of reliability for operations in urban areas UAVs' communication channels need security measure for safety reasons

#9	Professional	Autonomous	Cameras Standards/Certifications for DSA system components	GPS Common ICT infrastructure that ensures communications among UAVs-UAVs, UAVs-GCSs and UAVs-CAAs Necessary to invest in these measures to ensure reliable and safe BVLOS flights UAVs' communication channels need to be secured for safety reasons
#10	Professional	Autonomous	Cameras Standards/Certifications for components of DSA system	GPS Additional ICT measures to cover gaps of GPS Setup of common flight management system to coordinate and monitor UAVs
#11	Professional	Autonomous	Standards/Certifications for components of DSA system Emergency systems with trigger mechanism independent from main power source	GPS Additional ICT technology in support of GPS to make navigation systems more reliable UAVs' communication channels need to be secured for safety reasons

Table A3: results of respondent's interviews about UAVs technological features (** information not available).

Respondent #N°	Type	Manufacturer storage with direct shipment
#1	Academic	Not feasible option for E-retailer due to managerial and logistics reasons
#2	Academic	Not feasible option for E-retailer due to managerial and logistics reasons
#3	Professional	Interesting option for shops and/or restaurant chains offering ready-made meal delivery service, as UAVs can speed up delivery operations Attention to both parcel reception modality and qualitative status of parcel at the time of reception
#4	Professional	Not feasible option for E-retailer due to managerial and logistics reasons Feasible option for ready-made meal delivery, as traffic avoidance and direct-line flight can shorten time span of operations and enlarge customers' base
#5	Professional	n.d.**
#6	Professional	Especially in case of ready-made meal delivery service, this option is can result unfeasible due to potential labour policy and safeguard issues
#7	Professional	It is an interesting option for shops and/or restaurant chains offering ready-made meal delivery service, but end-customers have to exploit directly parcel reception
#8	Professional	Possible option for restaurant chains offering ready-made meal delivery service, but range of operations can relatively expand
#9	Professional	n.d.
#10	Professional	n.d.
#11	Professional	n.d.

Table A4: results of respondents' interviews about "Manufacturer storage with direct shipment" distribution design option (** information not available).

Respondent #N°	Type	Distributor storage with carrier delivery
#1	Academic	Hub and spoke model: a main Distribution Centre (CD) for freight consolidation and then transfer to smaller warehouses (named Urban Distribution Centres (UDCs)) where UAVs start B2C parcel delivery operations UDCs will exploit Ground Control Station (GCS) function
#2	Academic	Depending on UAVs' endurance, this design could assume two structures: - long endurance: UAVs start B2C parcel delivery operations from a main DC - short endurance: UAVs start B2C parcel delivery operation from a network of UDCs (hub and spoke model)
#3	Professional	Direct customer parcel reception in urban area is difficult due to scarcity of suitable space for safe operations, but more feasible for parcel deliveries in relatively densely populated areas (e.g. suburbs, rural areas), as environment is less complex Possibility to become the equivalent option to top class parcel delivery services (e.g. Amazon Prime Now) available in high densely populated areas
#4	Professional	Suitable option for E-market place businesses, as they usually locate Distribution Centres (DCs) relatively distant from customer base area
#5	Professional	Suitable option if structure follows the hub and spoke model: main DC and a network of smaller warehouses closer to areas of B2C parcel delivery operations Smaller warehouses will assume function of Ground Control Stations (GCSs)
#6	Professional	n.d.**
#7	Professional	n.d.
#8	Professional	This option can offer benefits both logistics service providers and end-customers, as it will be possible to drop parcels directly to end-consumers' address even (even if they are at the time of delivery) This design (especially if operations occur in core of urban areas) needs an additional ICT measure in order to cover GPS gaps and thus make autonomous UAVs sufficiently reliable DCs can be the starting point of UAVs' parcel delivery operations, but UAVs' propulsion systems have to achieve a level of endurance to cover a sufficiently large operational area DCs will assume the function of both UAVs' hangar and fixed GCS
#9	Professional	n.d.
#10	Professional	n.d.
#11	Professional	Solution that can be implemented only when gaps in batteries' efficiency (and by consequence endurance) will be solved.

Table A5: results of respondents' interviews about "Distributor storage with carrier delivery" distribution design option (** information not available).

Respondent #N°	Type	Distributor storage with last-mile delivery
#1	Academic	Hub and spoke model: main Distribution Centre (CD) exploits freight consolidation and then transfer to smaller warehouses (Urban Distribution Centres (UDCs)) where UAVs start parcel delivery operations UDCs will exploit Ground Control Station (GCS) function
#2	Academic	Depending on UAVs' endurance, this design could assume two structures: - long endurance: UAVs start B2C parcel delivery operations from a main DC - short endurance: UAVs start B2C parcel delivery operation from a network of UDCs (hub and spoke model)
#3	Professional	To deliver directly to end-customers in urban area can be hard task due to scarcity of space and safety issue, but operations can be more feasible in relatively densely populated areas (e.g. suburbs, rural areas) thanks to less complex environment Possibility to become the equivalent option to top class parcel delivery services (e.g. Amazon Prime Now) available in high densely populated areas
#4	Professional	Suitable option for E-retailers, as they usually locate Distribution Centres (DCs) relatively distant from customer base area
#5	Professional	Suitable option if structure reflects the hub and spoke model: main DC and network of smaller warehouses closer to urban areas and assume the role of fixed GCSs as well
#6	Professional	n.d.**
#7	Professional	n.d.
#8	Professional	It can offer benefits both logistics service providers and end-customers, as parcels can be dropped directly to end-consumers' address (even in case of their absence) This design (especially in core of urban areas) needs an additional ICT measure to cover GPS gaps and thus make UAVs sufficiently reliable in conduct operations If UAVs' operational endurance is sufficiently long, operations start from a main DC If UAVs' operational endurance is short, two alternatives: UDCs or integration of UAVs with delivery vans, which become mobile GCSs, and the operator coordinate and perform multiple deliveries simultaneously
#9	Professional	n.d.
#10	Professional	n.d.
#11	Professional	Idea consists in the integration of autonomous UAVs with delivery vans Vans become mobile GCSs and the operator coordinate and perform multiple deliveries simultaneously

Table A6: results of respondents' interviews about "Distribution storage with last-mile deliver" distribution network design option (** information not available).

Respondent #N°	Type	Manufacturer/distributor storage with customer pickup
#1	Academic	Interesting option because: - pickup points could be safe areas for UAVs B2C parcel delivery operations - possibility to serve several end-consumers through one parcel reception location (> efficiency of operations) It can require significant investments in facilities and ICT infrastructures that can be very demanding for single business organisation, as it needs an implementation on a certain dimensional scale
#2	Academic	As pickup points aim to replicate high density of deliveries, it can be an inefficient option if UAVs do not have a certain transport capacity Risk of duplication of infrastructures if single business organisation implement this design with negative consequences on both companies' finances and society (e.g. urban land use) Pickup points could be more useful for better products returns management Automatized pickup points are necessary to achieve higher operational efficiency
#3	Professional	Advantageous option for freight logistics and distribution providers because it offers the opportunity to have higher efficiency in conduct and management of operations It can be highly demanding for a single business organisation due to investments in facilities Potential risk of end-customers' dissatisfaction, as they might not perceive real benefits of UAVs delivery if they have to go to pickup point to collect parcel This design can offer the opportunity to manage products returns in a more effective and efficient way compared to other designs
#4	Professional	Advantageous design for logistics and distribution service providers, but demanding investments to develop network of pickup points risk overcoming potential benefits Pickup points have to be automatized to achieve higher operational efficiency
#5	Professional	This option would need considerable investments in facilities and ICT infrastructures, but it could be positively leveraged by exploiting night deliveries (food excluded)
#6	Professional	Interesting option if second-tier warehouses (UDCs) will assume the function of pickup points UAVs will start transport operations from DCs or cross-dock areas and end at UDCs
#7	Professional	n.d.**
#8	Professional	Feasible option, but it needs investments in ICT infrastructures to support GPS in order to make UAVs operations reliable and safe Pickup points have to be highly automatized to get operational benefits
#9	Professional	n.d.
#10	Professional	n.d.
#11	Professional	This design will assume a different configuration from the conventional one: pickup points will be integrated with buildings (e.g. flats complexes or skyscrapers)

Table A7: results of respondents' interviews about "Manufacturer/distributor storage with customer pickup" distribution network design option (** information not available).